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Table of contents

Skilled *Ukemi* Reduces the Risk of Head Trauma for a Person Thrown with a *Seoi-nage* Technique

By Haruo Murayama[1]; Masahito Hitosugi[2]; Yasuki Motozawa[2]; Masahiro Ogino[3]; Katsuhiro Koyama[4]

Abstract: *This study clarified the kinematics of the head of a judo practitioner when thrown with seoi-nage and confirmed the effect of the breakfall (ukemi) technique in preventing severe head injury biomechanically. One judo practitioner (tori) threw another judo practitioner (uke) four times. Kinematic data was obtained using a digital video camera. Both linear and angular accelerations were measured with a six degree-of-freedom sensor array affixed to the centre of uke's forehead. We analysed values of the Generalised Acceleration Model for Brain Injury Threshold (GAMBIT) computed from the measured linear and angular accelerations when uke was thrown with seoi-nage. The values were compared with those obtained using an anthropomorphic test device (ATD) to represent a judo practitioner not performing the ukemi technique in our previous study. When seoi-nage was performed, uke fell forward and uke's arm or shoulder made contact with the tatami. The linear and angular accelerations rose to peak values. The GAMBIT values were 0.041 ± 0.002 (means ± standard deviation). The GAMBIT values obtained for uke in this study were significantly lower than those obtained previously for the head-striking ATD (P = 0.014). We confirmed that skilled ukemi is effective in avoiding head contact and subsequent severe head injury when uke is thrown forward with seoi-nage.*

Keywords: *head injury; judo techniques; prevention; GAMBIT; ukemi; head hitting*

Severe head injuries, especially acute subdural hematomas (ASDHs), infrequently occur during judo practice and competition (All Japan Judo Federation, 2023; Kamitani et al., 2013; Nagahiro et al., 2011). Among throwing techniques, *o-soto-gari* is the most common cause of such injuries, followed by *o-uchi-gari* and *seoi-nage*. In contrast to the *o-soto-gari* and *o-uchi-gari* in which the recipient is thrown backwards, with *seoi-nage*, the recipient is thrown forwards. Therefore, *seoi-nage* has the highest incidence of serious head injuries among all forward-throwing techniques. (All Japan Judo Federation, 2023; Kamitani et al., 2013; Nagahiro et al., 2011).

We previously assessed the mechanisms of head injuries in judo biomechanically by an anthropomorphic test device (ATD, specifically the POLAR dummy, which is a pedestrian dummy used in vehicle crash testing) (Hitosugi et al., 2014; Murayama et al., 2013; Murayama et al., 2014; Murayama et al., 2020a). The mechanism of ASDH caused by backward throwing techniques, such as *o-soto-gari* in which the recipient's occipital head strikes the *tatami*, is thought to be due to rupturing of the bridging veins. Specifically, the greater the angular acceleration in the sagittal plane direction during the impact of the occipital head, the more likely it is to cause elongation and rupture of the bridging veins that run from the surface of the brain to the dural sinuses. (Nagahiro & Mizobuchi, 2014; Forbes et al., 2014; Greenwald et al., 2008; Depreitere et al., 2006; Kleiven, 2003; Ommaya et al., 2002; Huang et al., 1999; Gennarelli & Thibault, 1982; Ommaya & Gennarelli, 1974). In contrast to being thrown backwards, *seoi-nage* produced large values of angular acceleration in all directions during the impact of the anterior parietal regions of the head, which may lead to strains and deformations of the brain surface. Subsequent rupture of the cortical vessels possibly with cerebral contusion, as well as the rupture of bridging veins, is the major etiology of ASDH (Murayama et al., 2020a).

Ukemi is particular to judo and one of the most basic and important movements of judo (Matsumoto, 1996). Performing *ukemi* has been considered valuable for decreasing the applied acceleration to the head of the thrown person and thus reducing the impact of the head with the *tatami*. However, the impact-reducing effect of *ukemi* had not been examined quantitatively until our recent studies.

In our recent studies, which analysed forces applied to the head quantitatively, we noted the effect of *ukemi* tech-

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niques in preventing severe head trauma when a judo practitioner is thrown backwards (Murayama et al., 2020b; Murayama et al., 2021). The current study examined the head's kinematics and biomechanical parameters as a judo practitioner is thrown forward with seoi-nage. In addition, we compared the values of the Generalised Acceleration Model for Brain Injury Threshold (GAMBIT) with those obtained using the ATD in our previous experiment (Murayama et al., 2020a). The present study confirmed the effect of *ukemi* in preventing severe head injuries when a judo practitioner is thrown forwards.

MATERIALS AND METHODS

A male judo practitioner (*tori* [thrower]: age 33 years, height 166 cm, weight 82 kg, 5th dan) threw another male judo practitioner (*uke* [receiver]: age 32 years, height 172 cm, weight 90 kg, 5th dan) repeatedly (Figure 1). The same *tori* recruited for the ATD measurements in our previous experiment was chosen (Murayama et al., 2020a).

The experiment was conducted after obtaining written, informed consent from the participants. The study protocol was approved by the Research Ethics Committee of Dokkyo Medical University School of Medicine (No.22008).

In seoi-nage, *tori* breaks *uke*'s balance forward, or to the left/right front corner. *Tori* inserts *tori*'s left/right arm under *uke*'s left/right armpit, loads *uke* onto *tori*'s back, and throws *uke* over the left/right shoulder (Daigo, 2005) (Figure 1). *Seoi-nage* was chosen as the throwing technique as it often results in ASDH. *Tori* threw *uke* with *seoi-nage* four times; in each trial, *uke* performed *ukemi* sufficiently without *uke*'s head hitting the *tatami*.

A six-degree-of-freedom sensor array (comprising three accelerometers and three angular velocity sensors [DTS 6DX PRO, Diversified Technology Systems, Seal Beach, CA]) was attached at the centre of *uke*'s forehead and secured with self-adhesive tape. All data was recorded at a 10-kHz sampling rate. We measured linear accelerations of the head using a channel frequency class (CFC) 180 filter. We calculated angular accelerations from the angular velocities using a CFC 60 filter and differentiating the filtered data. From the linear and angular accelerations obtained for different directions, the resultant linear and angular accelerations were then calculated, as described in our previous study (Murayama et al., 2020a). Furthermore, we determined the GAMBIT values from the resultant linear and angular accelerations. Newman (1986) proposed the GAMBIT model, considering the effect of linear and angular accelerations within a unified criterion, as shown in equation (1).

$$GAMBIT = \left[\left(\frac{a(t)}{250} \right)^2 + \left(\frac{\alpha(t)}{25000} \right)^2 \right]^{\frac{1}{2}} \quad (1)$$

Here, $a(t)$ is the maximum linear acceleration (g); $\alpha(t)$ is the maximum angular acceleration (rad/s^2), and the values 250 (g) and 25,000 (rad/s^2) represent critical tolerance levels for these accelerations.

Kinematic data was captured for *uke*'s whole-body motions during the trials using a digital video camera. The GAMBIT values were then compared with those obtained in our previous experiment using the ATD. In that experiment, *uke* was thrown with *seoi-nage* and the ATD is considered to have recorded representative kinematics of *uke* not performing the *ukemi* technique. We applied a Mann–Whitney test; differences with a P value less than 0.05 were considered significant.

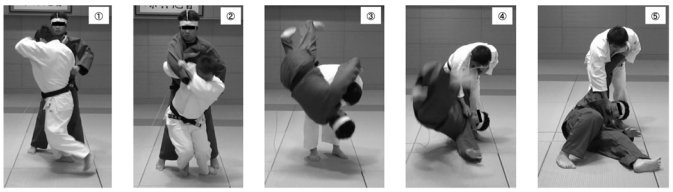

Figure 1. Semi-nage technique. Both the white (tori) and the black (uke) participants were judo practitioners.

RESULTS

The kinematic data shows that *uke* fell forwards without head contact with the *tatami* when executing *ukemi* in response to seoi-nage. Both linear and angular accelerations rose following the first body contact with the *tatami* (i.e., from the moment that the arm or shoulder made contact with the *tatami* until the legs made contact with the *tatami*) (Figure 2). The peak resultant linear accelerations were 9.0 ± 0.4 G (acceleration gravity; mean ± standard deviation), ranging from 8.4 to 9.3 G. The peak resultant angular accelerations were 756.7 ± 43.2 rad/s^2, ranging from 711.3 to 805.8 rad/s^2. Subsequently, the GAMBIT values computed from the acceleration data were 0.041 ± 0.002, ranging from 0.038 to 0.043. The GAMBIT values for the judo practitioner were significantly lower than those for the ATD (0.148 ± 0.087, ranging from 0.061 to 0.280) obtained in our previous experiment (P = 0.014) (Figure 3).

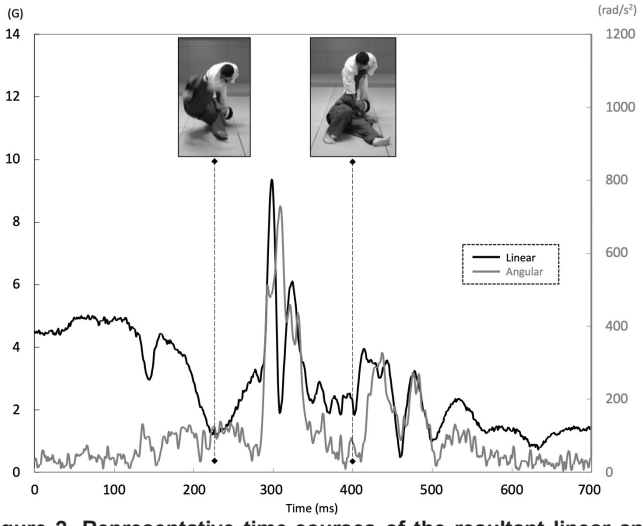

Figure 2. Representative time-courses of the resultant linear and angular accelerations during *seoi-nage*

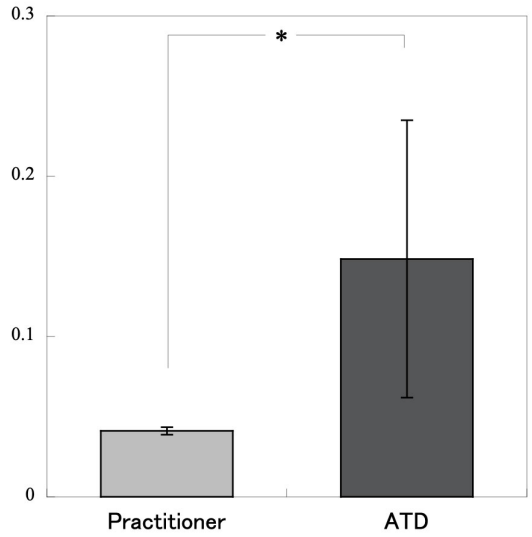

Figure 3. Comparison of the GAMBIT values between throwing the judo particioner and throwing the ATD in *seoi-nage* (*P < 0.05, Mann-Witney test). The ATD values were taken from Murayama et al. (2020a)

This study objectively clarified the kinematics and applied forces of the head of a judo practitioner who was thrown forward onto a *tatami* with *seoi-nage*. Regarding the mechanisms of injury from *seoi-nage*, Murayama et al. reported that when thrown forward, the anterior part of the head made contact with the *tatami*. Subsequently, large values of linear acceleration in the vertical direction maintained than the longitudinal and lateral directions, and large values of angular acceleration in each direction were observed [Murayama et al., 2020a]. Although the values of both linear and angular accelerations were less critical than those obtained in *o-soto-gari* or o-uchi-gari, serious neck injuries can occur as a result of neck compression following head contact with the *tatami* (Nakanishi et al., 2021).

We found that the linear acceleration of *uke* increased from the moment that the body first made contact with the *tatami*, whereas the angular acceleration increased a little later. Despite the head swaying around the neck owing to the initial contact with the *tatami*, direct head contact with the *tatami* was avoided through skilled *ukemi*. According to previous biomechanical analyses, when *ukemi* was not performed, the application of *seoi-nage* resulted in the direct contact of anterior parietal regions of the ATD's head with the *tatami* (Nakanishi et al., 2021; Murayama et al., 2020a). In contrast with the previous experimental data, the GAMBIT values were not elevated when *ukemi* was performed correctly without head impact, in the current study.

It has been shown that severe head injuries occur frequently for people with little judo experience (Kamitani et al., 2013); i.e., people who have not yet fully mastered *ukemi* techniques. The current study confirmed that the skilled judo practitioner can prevent severe head injury by performing *ukemi* adequately.

The present study had limitations. Firstly, the sensor was positioned on *uke*'s forehead. In earlier ATD trials, the sensor was placed at the centre of gravity of the dummy's head (Akiyama et al., 2001). Clearly, it is not feasible to place a sensor inside the head of a living person. Owing to the small distance between the forehead and centre of gravity, we consider that this limitation did not affect our results significantly. Secondly, there were only four experimental repetitions. However, the variabilities of the obtained values were not great, with the standard deviations being small, owing to the participants' high level of skill (5th dan) which enabled them to repeat accurate and reproducible attempts. We thus consider the results to be highly trustworthy.

In conclusion, it is crucial to use *ukemi* techniques skilfully to prevent the head from hitting the *tatami*, preventing severe head injury.

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The Final Battle!
Variability of Performance of Finalists in World Judo Championships

By Marcus Agostinho[1], Rafael Kons[2], Emerson Franchini[1]

Abstract: *The aim of this study was to investigate the technical variability of gold and silver medallist athletes who competed in the 2022 and 2023 judo world championships across different age categories (cadets, juniors, seniors) and sexes (male, female). The analysis included 176 finalist athletes, focusing on techniques, directions of kuzushi (breaking balance), grip configurations, actions before attacking (tachi-waza), and transitions to groundwork (ne-waza). The Kruskal-Wallis test was used to compare groups, followed by Dunn's post hoc comparisons, with the significance level set at 5%. Concerning sex, results indicated that males exhibit higher standing combat variability ($p<0.01$), while females presented greater groundwork variability ($p<0.05$). Gold medallists demonstrated higher variability in pre-attack actions and throwing techniques compared to silver medal winners ($p<0.05$). However, there was no effect of age categories ($p > 0.05$). These findings revealed distinct differences in scoring actions between male and female world championship finalists, highlighting characteristics that are extremely specific to athletes who reached the highest place on the podium in high-level competition, considering the variability of judo techniques.*

Keywords: *success factors; performance analysis; high level; martial arts*

In open-skill competitive sports, success depends on achieving a balance between stable and variable actions (Krabben et al., 2019). This balance is essential for athletes to adapt effectively to the ever-changing demands of their sport (Van Emmerik & van Wegen, 2000; Kons et al., 2022). Combat sports, particularly, present unique challenges, as athletes must continuously strategise to counter their opponents' moves and gain a competitive advantage (Hristovski et al., 2012; Krabben et al., 2018; Pinder et al., 2011). In judo, this dynamic interplay is especially evident, due to the complex nature of techniques in various directions and on both sides, requiring athletes to respond effectively in critical moments (Krabben et al., 2019). Technical variability is crucial for success in judo, offering athletes many tactical options during contests, linking closely to higher performance in official competitions (Agostinho & Franchini, 2021; Franchini et al., 2008).

At the highest levels of judo, such as the world championships or Olympic Games, small distinctions often determine victory or defeat. These differences can be attributed to physical factors (Franchini et al., 2011), psychological preparation (Ziv & Lidor, 2013) and technical-tactical performance (Franchini et al., 2008), all of which shape athletes' strategies. In this context, technical variability becomes a key factor for understanding athlete interactions and strategic behaviours (Kons et al., 2022; Franchini et al., 2008). Athletes deploy this variability right from the start of a contest, beginning with strategies for grips and initial movements (Krabben et al., 2022), continuing through the selection and execution of judo techniques (Kons et al., 2022; Krabben et al., 2019). This approach permeates every phase of engagement, as elite athletes often engage in more intricate phases of displacement and gripping situations before executing techniques, as demonstrated by Calmet et al. (2010), who noted that elite athletes engage in these phases more strategically and with greater speed than their less experienced counterparts. This increases unpredictability and strategic advantages against opponents.

However, limited research has examined technical variability among top-level judo athletes (Agostinho & Franchini, 2021; Kons et al., 2022; Franchini et al., 2008; Martins et al., 2019). Franchini et al. (2008) studied the technical variations of super-elite athletes (i.e., Olympic and world championship gold medallists) versus elite athletes (i.e., those finishing between 2nd and 7th place), finding that super-elite athletes exhibited a broader range of throwing techniques and directional variations. In contrast, Martins et al. (2019) reported that the top 10 throwing techniques accounted for about 50% of all scoring actions at the 2017 Judo World Championships, indicating a concentration of

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techniques at this level. Agostinho and Franchini (2021) found that among 296 judo medallists from the 2018 and 2019 world championships, gold medallists showed increased variability in pre-attack actions compared to bronze medallists, and higher transition variability. Similarly, Kons et al. (2022) observed that Olympic medallists exhibited more varied actions in both *tachi-waza* and *ne-waza* than non-medallists.

Exploring technical variability in specific groups of judo athletes, such as finalists, offers valuable insights into the technical determinants of victory at the highest levels. The rigorous path to the final stages of competition, which involves several contests against varied opponents and demands sustained focus, makes understanding variability in technical actions among finalists essential. This study, therefore, aims to analyse the technical variability of gold and silver medallists from the 2022 and 2023 judo world championships for cadets, juniors and seniors, comparing them by sex and age categories.

STUDY DESIGN

This descriptive study aimed to investigate technical variability among gold and silver medallists in the 2022 and 2023 judo world championships across different age categories (cadets, juniors, seniors) and sexes (male, female). These championships represent pivotal events in international judo, offering a comprehensive dataset for analysis. The study includes all gold and silver medallists from each age category and sex in the specified championships, focusing on the analysis of finalists' scoring actions retrieved from the International Judo Federation (IJF) website. After this, the contests were analysed to identify and assess the specific actions taken for each athlete.

PROCEDURES

All scoring actions of the 176 finalist athletes at the 2022 and 2023 judo world championships for cadets (32 males and 32 females), juniors (28 males and 28 females) and seniors (28 males and 28 females) were analysed. The number of contests each finalist participated in was also analysed. The number of techniques, directions of *kuzushi*, grip configurations, actions before attacking (for *tachi-waza*), groundwork technique groups, and forms of transition to *ne-waza* of all finalists' scoring actions were registered according to the variables suggested by Agostinho and Franchini (2021), as follows:

For scoring throwing techniques (*nage-waza*):

a) Grip configurations: grip configurations (*kumi-kata*) used in the scoring techniques, according to the holding place of each hand (sleeve-lapel, sleeve-collar, sleeve-sleeve, lapel-lapel, just one sleeve, just one lapel, sleeve-crossed lapel, sleeve-armhole, and dorsal variations such as over collar, waist and crossed);
b) Actions before attacking: patterns of actions before executing effective throwing actions, including forms of attack with grip control (directly after more than 5s and combined attacks/*renraku-henka-waza*), dynamic attacks (attack immediately after grip control and attack executed during the grip dispute), and opportunistic forms (counterattack/*kaeshi-waza*, attack immediately after opponent's attack/*go-no-sen*, and attack with opponent kneeling/*ne-shisei*);
c) Directions of *kuzushi*: combination of directions (forward or backward) and side (left or right) where the opponent (*uke*) was thrown, resulting in four possibilities (left backward, right backward, left forward and right forward);
d) Throwing techniques: number of different techniques that were scored by the referees, according to the nomenclature used by the International Judo Federation.

For scoring groundwork techniques (*katame-waza*):

a) Transitions to *ne-waza*: patterns of actions executed during the transition from standing position to groundwork combat, including direct (immediately after a scoring, throwing technique), sequential (after a throwing technique attempt), opportunistic (after a opponent's failed throwing technique), intentional (opponent's conduction to the ground), active defence (after executing a defensive action during groundwork) and groundwork sequence (combined attack when opponent defends the transition but the groundwork continues);
b) Groundwork groups: types of techniques executed (pin, strangle or elbow joint-lock techniques).

The performance analysis was conducted using the tagging system available on the International Judo Federation website (www.ijf.org), registering all variables with an application developed in a no-code app development platform (www.appsheet.com). An expert researcher, who is a black belt and judo coach, conducted the data tabulation and analysis. This approach has been shown to be efficient and reproducible in similar research. (Kons et al., 2022). No ethical committee was consulted before conducting this study, as the data was obtained in secondary form from a publicly available source, contains no personal information and was not generated through experimentation (Belmonte Report, 1979).

STATISTICAL ANALYSIS

Values are presented as median, 25th and 75th percentile values. Throwing techniques executed in standing positions (*tachi-waza*), directions of *kuzushi*, grip configurations, conditions before attacking, transition variation, and techniques executed in groundwork (*ne-waza*) were compared between age groups, sexes and podium positions via the Kruskal-Wallis test, followed by Dunn's post hoc comparisons when differences were found. The significance level was set at 5%. Eta squared (η^2) was used to determine the effect sizes, according to Cohen's classification (0.01, small; 0.06, moderate; 0.14, large) (Cohen, 1988).

RESULTS

The number of contests (Table 1) was different between sexes (H(1)=7.255, p=0.007, η^2=0.041, small) and age groups (H(2)=16.188, p<0.001, η^2=0.093, moderate), with a higher number of contests for males than females (p=0.007), and for senior athletes than cadet (p<0.001) and junior (p=0.001) athletes.

Table 1. Number of Contests of 2022 and 2023 World Championship Cadet, Junior and Senior Finalists

Sex	Age	Position	Contests
Female	Cadet	Gold	5 (4-5)
		Silver	5 (4-5)
	Junior	Gold	5 (4-5)
		Silver	5 (4-5)
	Senior	Gold	5 (5-5)[b]
		Silver	5 (5-5)[b]
Male	Cadet	Gold	5 (5-5)[a]
		Silver	5 (5-5)[a]
	Junior	Gold	5 (5-5)[a]
		Silver	5 (5-5)[a]
	Senior	Gold	5 (5-5)[ab]
		Silver	5 (5-6)[ab]

Note: values are median (25th and 75th percentiles). [a]Higher than females (p=0.007). [b]Higher than cadet (p<0.001) and junior (p=0.004).

Standing combat variation parameters are presented in Table 2.

Table 2. Standing combat variation parameters of 2022 and 2023 world championship cadet, junior and senior finalists

Sex	Age	Position	Grip configurations	Actions before attacking	Directions of *kuzushi*	Throwing techniques
Female	Cadet	Gold (n=16)	2 (1-2)	2 (2-3)[b]	2 (2-3)	3 (2-4)[b]
		Silver (n=16)	2 (2-3)	2 (2-3)	2 (1-2)	2 (2-3)
	Junior	Gold (n=14)	2 (2-3)	2 (1-3)[b]	2 (1-2)	2 (2-3)[b]
		Silver (n=14)	2 (2-3)	2 (2-3)	2 (2-3)	3 (2-4)
	Senior	Gold (n=14)	3 (2-3)	3 (2-4)[b]	2 (2-3)	3 (3-4)[b]
		Silver (n=14)	2 (1-3)	2 (1-3)	2 (1-3)	3 (1-3)
Male	Cadet	Gold (n=16)	3 (2-3)a	3 (2-4)[ab]	2 (2-3)[a]	4 (2-4)[ab]
		Silver (n=16)	2 (2-3)a	3 (2-3)[a]	3 (2-3)[a]	3 (2-3)[a]
	Junior	Gold (n=14)	3 (2-4)a	3 (2-4)[ab]	2 (2-3)[a]	3 (3-4)[ab]
		Silver (n=14)	2 (2-3)a	3 (2-4)[a]	2 (2-2)[a]	3 (2-4)[a]
	Senior	Gold (n=14)	3 (2-4)a	4 (3-5)[ab]	3 (2-3)[a]	4 (3-5)[ab]
		Silver (n=14)	2 (2-3)a	2 (2-3)[a]	3 (2-3)[a]	3 (2-3)[a]

Note: values are are median (25th and 75th percentiles). [a]Higher than females (p<0.05). [b]Higher than silver medallists (p<0.05).

Grip configurations. There was a main difference by sex for grip variation (H(1)=5.562, p=0.018, η^2=0.031, small), with males presenting higher variation than females (p=0.018).

Actions before attacking. The forms of attack variation in *tachi-waza* scoring techniques were different between the sexes (H(1)=10.461, p=0.001, η^2=0.060, small) and positions (H(1)=4.256, p=0.039, η^2=0.024, small), with post hoc Dunn tests indicating higher variation for males than females (p=0.001) and for gold than silver medallists (p=0.039).

Directions of *kuzushi*. For *tachi-waza* directions, a main difference by sex (H(1)=4.012, p=0.045, η^2=0.023, small) was found. The post hoc test indicated that males attacked in more directions of *kuzushi* than females (p=0.045).

Throwing techniques. Main diference by sex (H(1)=7.493, p=0.006, η^2=0.043, small) and position (H(1)=7.770, p=0.005, η^2=0.044, small) were also found for technique variation, with males (p=0.006) and gold medallists (p=0.005) showing higher variability than female and silver medallists, respectively.

Table 3. Groundwork Variation Parameters of 2022 and 2023 World Championship Cadet, Junior and senior Finalists

Sex	Age	Position	Transitions' forms	Groundwork groups
Female	Cadet	Gold	1 (1-1)*	1 (1-1)*
		Silver	1 (0-2)*	1 (0-1)*
	Junior	Gold	1 (1-2)*	1 (1-1)*
		Silver	1 (1-2)*	1 (1-1)*
	Senior	Gold	1 (1-2)*	1 (1-1)*
		Silver	0 (0-1)*	0 (0-1)*
Male	Cadet	Gold	1 (0-2)	1 (0-1)
		Silver	1 (0-1)	1 (0-1)
	Junior	Gold	1 (0-1)	1 (0-1)
		Silver	0 (0-1)	0 (0-1)
	Senior	Gold	0 (0-1)	0 (0-1)
		Silver	0 (0-1)	0 (0-1)

Note: values are median (25th and 75th percentiles). *Higher than males (p<0.001).

Transition forms and groundwork groups. There was a main difference by sex for transition from *tachi-waza* to *ne-waza* variation (H(1)=13.851, p<0.001, η^2=0.079, moderate), with females presenting greater variation than males (p<0.001), as well as for variation in *ne-waza* (H(1)=12.578, p<0.001, η^2=0.072, moderate), with greater variation for females than males (p<0.001).

DISCUSSION

The present study found some differences between male and female world championship finalists in their scoring actions, with males showing higher standing combat variability (grip configurations, actions before attacking, directions of *kuzushi*, and techniques) compared to females. In contrast, females presented greater groundwork variability (transition forms and groundwork groups) than males. Additionally, gold medallists showed greater variability than silver medallists for the number of actions before attacking and throwing techniques used in their scoring contests.

Similar results to the present study were observed in the 2018 and 2019 world championship medallists regarding differences in the sexes for grip configurations, actions before attacking, throwing techniques, and directions of *kuzushi* (Agostinho; Franchini, 2021). Observing 36 international competitions, Dal Bello et al. (2019) also found that male athletes used more variations of grip configuration during their contests compared to female athletes. As male finalists analysed in the present study had to fight more contests than female finalists, it is possible that they needed to adapt their system of attack with greater variability, to be less predictable in standing combat in order to advance in this level of competition.

Conversely, the female finalists showed higher *ne-waza*-related variability than male finalists, corroborating the higher female's *ne-waza* variation index (number of effective groundwork groups divided by number of contests) observed in Tokyo Olympic Games 2021 participants (Kons et al., 2022). This higher effectivity for female compared to male judo athletes in groundwork combat was also observed in tied matches (Nagai et al., 2019). This result clearly indicates that female finalists presented greater variation in judo-specific techniques, showing a specific versatility of this group throughout high-level competitions.

Another possible explanation for these differences between the sexes could be some distinctions observed in standing and groundwork accumulated durations. In this sense, longer standing combat and longer gripping action times were found in male cadet athletes, compared with female cadets athletes (Miarka et al., 2020), as well longer accumulated duration of groundwork combat were found for extra lightweight and heavyweight females compared to males in similar weight categories (Sterkowicz-Przybycien et al., 2017). Although time-motion ana-

lyses were beyond the present study's scope, it seems that coaches and athletes may be adapting the system of attack according to recent international competition rules and tendencies, developing specific tactics to search for scores in groundwork that are proving more effective for female elite judo athletes.

Gold medallists presented higher standing combat variability in their actions before attacking and throwing techniques when compared with silver medallists. Other studies showed level differences between gold and bronze world championship medallists for actions before attacking (Agostinho & Franchini, 2021) and between super-elite and elite judo athletes for the number of different throwing techniques (Franchini et al., 2008). These results reinforce that world champions present a less predictable system of attack, using different throwing techniques and executing these techniques with different forms of attack. Importantly, no significant differences were found in the technical variability between the different age categories of athletes. This lack of variation may be attributed to the fact that athletes at all levels, such as gold and silver medallists, demonstrate a high degree of technical variability in their judo techniques in high level competitions (Agostinho & Franchini, 2021).

Some limitations should be addressed in this study: (a) our analysis focused specifically on finalists of the 2022 and 2023 judo world championships, which is a relatively small sample, although at the highest elite level, potentially limiting the generalization potential of the findings with regard to the other levels of judo athlete; (b) time-motion analysis did not include the standing and groundwork combat phases, which could provide valuable context for the observed technical variability. Future research could benefit from incorporating temporal variables (e.g., contest duration) and kinematic factors, as these are crucial components of judo performance.

CONCLUSION

The present study revealed differences in scoring actions between male and female world championship finalists. Males exhibited higher variability in standing combat, such as grip configurations, actions before attacking, directions of *kuzushi*, and techniques, compared to females. In contrast, females demonstrated higher variability in groundwork, including transition forms and groundwork groups compared to males. Additionally, gold medallists showed greater variability than silver medallists in the number of actions before attacking and the throwing techniques used in their scoring actions, something extremely specific to the group of athletes who occupy the highest place on the podium.

In practical terms, these aspects highlight the importance of variability in both standing and groundwork actions during contests to achieve success in those judo contests. Coaches and athletes should consider these findings, to improve training methods and technical-tactical strategies to achieve or maintain the level of performance of athletes in top-level international championships.

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Myths and Facts Surrounding Knowledge of the Relationship Between the Menstrual Cycle and Performance

Perceived Knowledge Regarding Elite Female Judoka in an Olympic Cycle

By Katryna Esposito

Abstract: *The menstrual cycle influences the physical and psychological states of female athletes significantly, especially those participating in high-intensity sports like judo. This study investigates how elite female judoka understand and experience their menstrual cycles, as well as the impact these factors have on their training, competition performance and overall health. Utilising qualitative methods, insights were collected from sixteen elite judoka aged 18 to 30, who competed in Olympic qualifying events from June 2023 to June 2024 via a structured online survey. The responses were analysed through inductive latent thematic analysis, a method that aims to identify patterns and themes within qualitative data. This approach revealed several key themes related to the experiences of these athletes.*

The analysis revealed that the menstrual cycle poses challenges for these athletes, including fluctuations in energy levels, mood swings and physical symptoms such as fatigue and cramps, all of which can impede performance. The research underscores the need for increased awareness of menstrual health in sport and advocates for training programmes tailored to the unique needs of female athletes across different menstrual phases. Promoting open discussions about menstrual health can help de-stigmatise support-seeking behaviour. The study calls for evidence-based guidelines to assist athletes and coaches in managing the effects of the menstrual cycle on performance, ultimately supporting the wellbeing and competitive success of female judoka.

Keywords: *menstrual cycle; menstruation; elite female judoka; performance; weight cycling; mental health*

INTRODUCTION

What is the Menstrual Cycle?

The menstrual cycle, as elucidated by Presser's seminal work in 1974, is defined by a 28 ± 2.4-day duration comprising four distinct phases governed by intricate hormonal interactions. Subsequent research by Simmen and Simmen (2006) delineated the initiation of the cycle at the follicular phase, encompassing menstruation and progressing into the late follicular phase, marked by rising oestrogen levels and culminating in ovulation. This phase is characterised by a surge in follicular stimulating hormone (FSH) and luteinising hormone (LH), with FSH peaking during the pre-ovulatory phase. Following this peak, FSH levels decline while LH stabilises before decreasing. Ovulation typically occurs 36 hours post-FSH peak, heralding the cycle's third phase. Preceding ovulation, oestrogen levels reach a peak before declining during the subsequent luteal phase, where progesterone levels begin to ascend. The luteal phase spans from ovulation to pre-menstruation, concluding with a decline in progesterone levels. Notably, progesterone plays a pivotal role in enhancing the secretory functions of the uterine endometrium, priming it for potential ovum implantation in the latter half of the menstrual cycle (Righi & Barroso, 2022).

Oestradiol's multifaceted role extends to the development of primary and secondary sexual characteristics. Subtle variations in oestradiol and progesterone levels throughout the menstrual cycle can manifest in a spectrum of adverse symptoms, including pain, fatigue, weight fluctuations (due to water retention and cravings), sleep disturbances and mood disorders (Chabbert-Buffet, 2007). Furthermore, these hormonal fluctuations intricately modulate fluid regulation, cardiovascular dynamics, aerobic and anaerobic performance, thermoregulation, muscular responses, orthopaedic functions, and metabolic reactions, collectively influencing adaptability, performance and training responses among individuals (Constantini et al., 2005).

The orchestration of the menstrual cycle emanates from the complex interplay of hypothalamic, hypophyseal and

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ovarian hormones, orchestrating modifications in the female reproductive system and myriad bodily tissues. This cyclical phenomenon comprises two pivotal phases characterised by dynamic hormone oscillations: the follicular phase and the luteal phase. Changes induced by external hormone administration can exert profound impacts on athletic performance. Oestrogen's influence extends across the cardiovascular system, substrate metabolism and neurocognitive functionality, while progesterone and related progestins predominantly modulate thermoregulatory mechanisms, ventilation dynamics and the selection and utilisation of energy substrates (Brown et al., 2020). Notably, elevated body temperatures can hasten fatigue onset detrimentally during prolonged exertion (Janse de Jonge, 2003; Charkoudian & Stachenfeld, 2016).

Why is it Important to Research Menses in Elite Athletes?

In 2005, Torstveit and Sundgot-Borgen conducted research on the prevalence of the female athlete triad among elite athletes, identifying three main components: menstrual dysfunction (amenorrhea), low energy availability (with or without disordered eating) and osteoporosis or low bone mineral density. They concluded that athletes engaged in sports requiring low body weight or leanness are at heightened risk of the Triad, with disordered eating and eating disorders being more prevalent among athletes. Amenorrhea was also significantly more common in the athletic population (3-66%) than in the general female population (2-5%) (Torstveit & Sundgot-Borgen, 2005). This prevalence is attributed to the unrealistic pressure to achieve a low body weight, increasing the likelihood of developing disordered eating. While Torstveit and Sundgot-Borgen (2005) noted that athletes used healthier weight-control strategies than controls, they also found higher percentages of menstrual dysfunction among athletes competing in leanness sports, endurance sports and weight-class athletes with lower mean body weights.

Czajkowska et al. (2020) further observed that athletes were at a higher risk of primary and secondary amenorrhea, with menstrual dysfunction being up to two or three times more frequent than in non-athletes. They noted that participation in competitions and long-term training periods could weaken ovarian activity, leading to irregular menstruation or luteal phase defects. Heavy bleeding and longer luteal phases were among the significant disorders observed, resulting in extended breaks between menses. Recacha-Ponce et al. (2023) emphasised the importance of studying even minor changes in performance due to the menstrual cycle, as female athletes constantly strive for optimal performance in competitive settings (Leal Cortes et al., 2021).

Impact on Performance and Health

In their study of two cohorts, McNulty et al., 2020 reported that the regularity of meals and weight-reducing diets did not show a statistically significant impact on the prevalence of premenstrual syndrome (PMS) and premenstrual dysphoric disorder (PMDD). PMS specifically presents as psychological, behavioural and physical challenges in the days leading up to menses. This may impact one's concentration, attention, motivation and speed. Even in a healthy, normal menstrual cycle, hormonal fluctuations during one's cycle, especially during the luteal phase, may affect growth hormone (GH) secretion as a response to exercise and this may enhance recovery and anabolic reactions post-exercise (Ángeles Arenas-Pareja et al., 2023). Additionally, coaches and clinicians must be aware that female youth and adolescent athletes are at a greater risk of certain types of injuries, including concussions, musculoskeletal injuries and the Female Athlete Triad, characterised by low energy availability, with or without disordered eating, menstrual dysfunction and low bone mineral density (Righi & Barroso, 2022).

Studies by Itaka et al. (2022) and Eken et al. (2022) highlighted the impact of menstrual cycle phases on sports performance. Itaka et al. (2022) observed decreased performance during the early follicular phase, particularly in weight-restricted sports, due to menstrual irregularities caused by energy availability, low fat and physical stress. Post-menstrual recovery was suppressed in athletes in these sports, leading to a reduced ability to maintain homeostasis. Eken et al. (2022) noted higher muscle power and strength among judoka in the afternoon compared to the morning, with plasma volume changes affecting heart rate and cardiac output.

Yapici-Öksüzoğlu and Egesoy (2021) emphasised the impact of hormonal variations within the menstrual cycle on sports performance, highlighting that a regular menstrual cycle allows athletes, particularly endurance athletes, to perform successfully during menses. They observed higher maximum power and anaerobic capacity values during the follicular phase compared to the luteal phase. Stefanovsky et al. (2021) studied judo athletes' performance through different menstrual cycle phases using the Wingate test, finding no significant differences. However, Ángeles Arenas-Pareja et al. (2023) noted variations in external load during ovulation and the late follicular phase, favouring intense short-duration exercises.

Individualised Approach, Awareness and Healthcare

Meignié et al. (2021) stressed the importance of an individualised approach with athletes due to their varied responses to training stimuli, leading to menstrual disturbances such as anovulation, oligomenorrhea, amenorrhea, and irregular menstruation, more prevalent among elite athletes (Redman and Loucks, 2005). McNamara et al. (2021) found that two-thirds of elite female athletes perceived their menstrual cycle to affect their performance, contrary to some previous findings showing trivial effects. Bergström et al. (2023) observed that while many athletes experienced menstrual cycle-related symptoms, only 27% discussed them with their coach.

There is little awareness regarding the potential risks of relative energy deficiency in sport (RED-S) and its link to healthcare risks. RED-S, caused by imbalances between energy uptake and consumption, can result in physiological disruptions affecting basal metabolism, bone density, menstrual cycle, cardiovascular health, and the immune system. The normalisation of amenorrhea and athletes' failure to seek help for amenorrhea, a well-known consequence of RED-S, contribute to these risks (Verhoef et al., 2021; Coelho et al., 2021).

Menstrual Symptoms, Performance and Physiological Implications

Based on a study by Czajkowska et al. (2020), factors such as age, age at menarche, years in sport, and training intensity can increase the risk of PMS and PMDD in young female athletes. Additionally, alcohol and coffee consumption are significant risk factors for these conditions. However, the study's findings were limited by a small sample size and reliance on subjective symptom reporting.

Kishali et al. (2006) reported that 14.5% of athletes had menstrual disorders under normal conditions, which increased to 20.7% during intensive exercise. 11.6% used drugs during competition, 36.9% experienced painful menstruation, and 63.1% reported decreased pain during competition. Athletes experienced no performance change between the non-menses and menses periods. In this study, only 26.1% of the athletes interviewed participated at the international level.

When looking at Mood Disorder Questionnaire (MDQ) scores in female judoka of different weight categories, Itaka et al. (2022) found that in the postmenstrual period, the MDQ scores for autonomic nervous system incoordination were higher in the lightweight class compared with the medium and heavyweight classes (P = 0.037, 95% CI 0.021 - 0.669). Similarly, poor concentration (P = 0.046, 95% CI 0.012 - 1.369) and water retention (P = 0.030, 95% CI 0.044 - 0.837) were also elevated in the lightweight class. Moreover, the scores of negative effects tended to be higher in the lightweight class than in the medium and heavyweight classes after menstruation (P = 0.053, 95% CI -0.103 - 1.415). No significant differences were observed in the other parameters between the medium and heavyweight classes or in the lightweight class during the premenstrual, menstrual or postmenstrual periods.

The study has limitations, including a small number of participants in the heavyweight class, which may have affected statistical results, leading to a less representative sample. Additionally, physical parameters like body fat and skeletal muscle mass were not measured, so their influence on the MDQ scores among weight classes cannot be discussed.

In their study, Brown and Knight. (2021) reported that elite female athletes experience varied impacts of the menstrual cycle on training and performance. They suggested creating open discussions and protocols for addressing these effects. The study focused only on elite athletes and may not represent the experiences of junior athletes or athletes in traditional female sports.

Yapici-Öksüzoğlu and Egesoy (2021) examined the menstrual cycles' metabolic, cardiovascular and respiratory effects. They observed notable variations in peak power and fatigue index values throughout different phases of the menstrual cycle. The study is limited due to the small participant sample size and focus on university team athletes. The research specifically analysed day 2 and day 14 of the menstrual cycle. Similarly, Aitkenhead et al. (2023) suggest that higher oestrogen levels during certain phases can benefit energy metabolism and muscle glycogen storage for high-intensity, short-term exercises. The menstrual cycle did not influence physiological responses and training variables significantly in well-trained and elite female athletes. However, individual fluctuations were present, so athletes were recommended to monitor their own cycle to optimise training and performance. The study used urinary ovulation kits, Basal Body Temperature tests (BBT) and manual tracking to determine the cycle phase, due to the limitation of not being able to conduct hormonal verification via blood serum. Additionally, the study was underpowered and would require a larger cohort for more significant results.

Belanger et al. (2013) and Herzberg et al. (2017) explored the connection between hormone levels, particularly oestradiol, and knee joint flexibility and stiffness. They observed fluctuations throughout the menstrual cycle, noting that during ovulation, there were positive correlations between oestrogen levels and anterior cruciate ligament (ACL) stiffness. This has implications for injury risk and performance outcomes, as increased lower-body stiffness is linked to improved physical performance and reduced injury risks (Legerlotz & Nobis, 2022). Additionally, Herzberg et al. (2017) reported in their systematic review and meta-analysis that recent studies suggest oral contraceptives could potentially reduce ACL injury risk by up to 20%, albeit with low overall strength of evidence. Future research could involve long-term observational studies with hormonal assays and large trials of follicular suppression using newer hormonal methods. Notably, athletes experiencing menstrual disorders, such as primary and secondary amenorrhea, dysmenorrhea and others, were found to be at increased risk of relative energy deficiency in sport (RED-S), which can lead to potential health complications and performance decrements (Vogel et al., 2023; Leal Cortes et al., 2021).

Awareness and Management

Brown et al. (2020) highlighted the lack of awareness and dialogue surrounding menstrual symptoms among elite athletes. Many athletes reported experiencing physical symptoms, mood disruptions and decreased motivation for training, with some modifying their training intensity and workload to cope with these challenges. Some athletes also associated amenorrhea with RED-S, emphasising the need for vigilance and management strategies to mitigate health risks (McNamara et al., 2021). Monitoring symp-

toms and cycle patterns can aid athletes in managing their menstrual cycles effectively, reducing anxiety and stress during competitions. Elite athletes also need to compete at a high level in regular international events, making them more sensitive to training individualisation (Meignié et al., 2021).

Pre-menstrual Coping Measures (PMCM) were tailored for the sporting context to mitigate distress among individuals and situations. However, elite athletes often face unavoidable premenstrual distress, leading to reduced exercise levels due to external and internal pressures related to competition, training and performance. The primary coping strategy involves minimising harm and adjusting energy levels, with indirect functional impacts including communication, self-care practices, awareness and acceptance during pre-menstrual periods (Modena et al., 2022).

Looking Beyond

Numerous studies have delved into the effects of training on the menstrual cycle. Still, few have examined these effects in weight-cutting sports specifically or among elite athletes during an Olympic qualification year. Most studies have also overlooked participants' individual experiences, perspectives and knowledge and included a diverse group of high-level athletes with diverse cultural backgrounds. During the Paris 2024 Olympic Games, the average age of female participants was 26.35, with the youngest being 17 and the oldest being 38 years old.

Therefore, this study sought to address these gaps by assessing the current knowledge level of a sample of elite judoka and identifying areas that require further exploration. Additionally, the study aimed to raise awareness among participants about the physiological and psychological effects associated with menstruation, encouraging an open dialogue around a topic that is still considered taboo in some circles (e.g., Brown et al., 2020). Finally, it proposed potential areas for further development through educational programmes and training for athletes, coaches and administrators. This may improve prepararation for high-level judoka and address the challenges they face in a receptive and holistic environment.

METHODOLOGY

Participants

Sixteen elite female judoka between the ages of 18 and 30 years (μ 24.25, SD 3.17), competing in Olympic qualifiers at the time of the study, responded to the call for participants. Each participant had competed in Olympic qualifying events as listed in the World Judo Tour calendar, such as continental opens, continental championships, grand slams, grand prix or world championships, between June 2023 and June 2024. These participants were from the five continental unions and represented different weight classes, ranging from -48 kg to +78 kg.

All participants met the following criteria: aged between 18 and 30 years, possessing a basic understanding of and ability to write in English, competing in Olympic qualifying events on the World Judo Tour at the time of the study, representing various weight classes, and being members of different continental unions. Each participant, competing under their national federation, was assumed to be fit for competition as determined by their respective federation.

Before completing the survey, participants were informed of the study's purpose and potential risks. They were also informed that withdrawing from the survey at any point would not result in any disadvantages. Informed consent was obtained from all participants before any data was collected. The study received ethical approval from the Staffordshire University Ethics Committee.

Study Design and Data Collection

This qualitative study utilised a structured online survey. A mixed method approach was taken to collect qualitative, descriptive primary data, as well as quantitative descriptive data due to time zone differences, conflicting competition schedules and periodisation programmes. An online survey was chosen as the most feasible data collection method. An online survey also helps with organic data collection, decreases any pressure of group opinions and may decrease feelings of being judged, allowing participants to be more comfortable and open with their responses. Invitations to participate in the survey were distributed by the researcher at various competitions and shared on appropriate social media platforms.

Open-ended questions were used to compare participants' first-hand experiences and opinions descriptively regarding their menstrual cycle and its impact on their performance. The sub-sections of the questionnaire included general information, information on their menstrual cycle, diet and weight-cutting, coach-athlete relationship, support and management and personal views (Table 1).

Female judoka were provided with a link to the online survey, which consisted of seven sections and 29 questions. The survey questions covered topics ranging from general information about their menstrual cycle to challenges related to weight-cutting and the socio-cultural impact on the support they received. The survey took approximately 15-20 minutes to complete. Microsoft Forms was used to collect the data and the responses were interpreted via inductive, latent, thematic analysis whilst describing sample statistics (Braun & Clarke, 2006; Crosley & Rautenbach, 2021).

A thematic analysis involves identifying, analysing and reporting patterns within qualitative data. In this study, an inductive approach was adopted, allowing themes to emerge organically from participants' responses. The data was meticulously read, with potential patterns noted, leading to the generation of initial codes. These codes were then grouped

based on their similarities, forming several themes that represent and report the data effectively. These themes were used to interpret any underlying meaning in the data. This is relevant because participants are asked about first-hand experiences and views.

The research was in a relatively new, under studied area. The results obtained can be considered reliable due to organic data being gathered. Clearly defined research questions were established to investigate the knowledge and perceptions of elite female judoka regarding their menstrual cycle's impact on their athletic performance. The study focused on how these athletes perceive their menstrual cycle affects their performance and general health, aiming to provide credible and authentic insights into athletes' perceptions of the relationship between the menstrual cycle and athletic performance. Data was gathered through purposeful and snowball sampling, among a relevant and target population, allowing the study to be replicated easily and in an unbiased manner. Specific focus was placed on their perceptions being used to generate codes and themes.

Ethical Consideration and Risks

Survey questions were designed to minimise potential risks by allowing participants to delve into as much detail as they felt comfortable with. Participants were given the freedom to withdraw from the survey at any time or to skip any questions they did not wish to answer, minimising the potential for psychological and emotional stress. They were provided with sufficient information on how to withdraw their data should they change their mind within two weeks after submission. Anonymity was assured, with no identifying information collected or stored.

Table 1: Sample Questionnaire Distributed to Participants

Questionnaire Section	Sample Questions
General information	• Have you taken part in at least 1 Olympic qualifying event between June 2023 - 2024? • How old are you? • Which continental union do you form part of? • Which weight category do you compete in? • On average how much weight do you lose prior to competing?
Information on your menstrual cycle	• How old were you when you got your first period? • Do you get regular periods? • Have you experienced any symptoms as a result of your period? • Please explain if and how any of these symptoms affect your ability to train or perform? • Describe how your menstrual cycle affects your ability to cut weight? • Do you adjust or modify training intensities or sessions based on your cycle? • If you could pick an ideal time to compete at a very important event, when would you pick?
Diet and weight-cutting	• Do you feel you require any additional supplements to help with recovery, training or general health to keep up with your high training load especially due to your menstrual cycle? • Have you ever heard of Relative Energy Deficiency in Sport (RED-S) or Low Energy Availability (LEA)? • When cutting weight how does having your period affect your ability to keep up with training demands? • Do you think that female judokas may be more at risk of developing one of these syndromes and why? • If you feel female judokas cutting weight are at more risk of developing RED-S or LEA, why do you think many of them still cut weight?
Coach-athlete relationship	• In your opinion are you able to speak to your coach about issues you may face as a result of your menstrual cycle? • How do you feel about talking to your coach about any challenges you may face resulting from your menstrual cycle, do you feel she/he can understand and support you? • Is there anything you do to help manage your menstrual cycle and performance requirements?

Support and management	• Do you track your cycle via an app? • Please explain how you manage your menstrual cycle. • Do you feel you get enough support to manage your menstrual cycle and performance, please specify from who? • Have you ever visited a specialist and discussed your menstrual cycle along with training or performance requirements?
Personal views	• In your opinion how do you feel training types, intensities or overall periodisation should be structured based on an athlete's cycle phases? • In an ideal world would you adapt your periodisation plan to your cycle? • How important do you think it is to research topics such as menstrual cycle and performance?

RESULTS

This study aimed to evaluate the current knowledge of elite female judoka about their menstrual cycle and its effects on their ability to perform, while identifying areas that necessitate further exploration. Moreover, the study endeavoured to raise awareness among participants about the physiological implications of menstruation and to encourage open dialogue around a subject that is still considered taboo in some spheres.

In addition, it proposed potential areas for further advancement through educational programmes and training for athletes, coaches and administrators. That will better equip high-level judoka and address the challenges they encounter in an increasingly open and comprehensive setting.

Demographic Information

Most of the participants (37%) were in the 24-26 age group, followed by 21-23 years old (25%). The remaining participants were evenly distributed among the other age ranges. Five (31%) of these participants were affiliated with the European Judo Union and the Pan-American Judo Confederation, respectively. Three (18%) were affiliated with the Oceania Judo Union, two (12%) with the African Judo Union, and one (6%) with the Judo Union of Asia. Participants were spread across various weight classes, with the most prevalent being the -57 kg (31%) and -70 kg (25%) categories. Excluding five participants who did not cut weight, participants lost 3.13 kg on average. Through analysis, several themes and sub-themes were uncovered as seen below (Table 2).

Main Findings

Through the study, nine themes emerged, including; physical effect, psychological effect, lack of understanding and limited action, perceived understanding and support, better understanding and empathy, training and effort, medical intervention, rest and supplements and lastly diet. Within these themes, 23 sub-themes were formed, and can be found listed below (refer to Table 2).

Table 2: Groups, themes and sub-themes identified via thematic analysis

Main Groups	Theme	Subthemes	Codes
Challenges (when training, dieting, cutting weight)	**Physical effect**	Discomfort	Cramps, heavy bleeding
		Fatigue	Fatigue (no energy and can't move)
		Pain	Pain during training, lower back pain
		Weak or less powerful	Can only train hard 2 out of 4 weeks, can't keep up with load
			Looser joints, feel weak especially in back and joints so avoid training hard
			Less power, more chance of injury
			Water retention

Challenges (when training, dieting, cutting weight)	**Psychological effect**	Lack of focus	Hard to focus when tired
		Emotional	I feel disappointed and not fit enough
			Overly emotional, can't focus; bad session, crying when something ruins my session
	Unsure	No effect	Don't think it affects me
Knowledge and support	**Lack of understanding and limited Action**	Male coach doesn't help	I tell him but he can't do much
			I don't talk to them
		Male coach doesn't understand	Uncomfortable to talk to as he wouldn't understand
			Doesn't understand but would sympathise
		Lack of knowledge from support systems	Lacks knowledge and understanding he thinks it's due to lack of training or sleep
			I am left to myself to try to manage it, when severe cramping contributes to a loss the coach is unsympathetic. My primary care physicians do not work with high performance athletes, I do not feel that they can provide adequate care for my needs.
		OBGYN doesn't understand demands of sport	Visited a gynaecologist because I was having my period twice a month. She prescribed birth control to me without providing any explanation of why this might be happening to me, even though she knew my background in sport. She also didn't bother giving me any tests.
	Perceived Understanding and Support	Male coach, sympathises	I think he would understand.
			Sympathetic but not empathetic.
		Male coach, supports but no help management	He would be supportive but would leave it to me to manage.
	Better Understanding and Empathy	Female coach, understands, easy to talk to	The coach was also my partner, so she understands, easy to talk to.
		Male coach, good knowledge and understanding	He knows when I'm on it to change my training schedule but other times he knows I must be tough and train as top-level athletes do.

Knowledge and support	**Better Understanding and Empathy**	Knowledgeable and understanding OBGYN	The OBGYN I go to is knowledgeable with holistic approaches such as acupuncture, teas, dietary needs and vitamins.
	Training and Effort	Ignore any symptoms	No, I think it's important to get used to training and putting the effort in so I can do it in competition.
Management	**Medical intervention**	Hormonal birth control	IUD to stabilise hormones
			Contraceptive pill
		Pain medication	Take painkillers
	Rest and supplements	Rest	More rest
		Supplements	B12, vitamin D, iron, folic acid and vitamin C
	Diet	Diet	Eat clean, drink water and keep things moving by exercising regularly.
		Diet	Chocolate and eat healthy meals, more water.
		Water	Drink more water.

Challenges Faced

Two participants experienced menarche at ages 10 and 11, five by age 12, four by age 13, and two each at ages 14, 15 and 16, respectively. All participants experienced menses, with seven (38%) having regular periods, eight (44%) experiencing irregular periods, one (5%) occasionally missing a period, one (5%) having menses more than once a month, and another one (5%) having irregular periods without further clarification.

The challenges faced could be divided into two themes: physical and psychological, with corresponding sub-themes describing fatigue, weakness, cramps, bloating, breast tenderness, and discomfort as physical symptoms. A key quote showing the physical challenges was, “Heavy bleeding and severe fatigue make training difficult.” The most common psychological sub-themes described were: loss of focus, mood swings and feeling emotional. Key quotes included, “Sometimes I feel emotional before/after training and I can feel weak, especially in the back and joints so I avoid training hard” and, “Can't keep up with load so I feel disappointed and not fit enough.” There were also quotes reflecting both physiological and psychological repercussions, “Overly emotional, can't focus, leading to a bad session” and “Affected physically, being unable to keep the load which also leads to feeling disappointed.” Interestingly, only a single athlete stated that she was not affected by her menstrual cycle.

Mangement

More than half (56%) of the respondents reported difficulty due to water retention and food cravings before their period, “The week prior and week after makes it the most difficult as my body is more fatigued and I have difficulty doing as much physical activity as my body needs more water to function properly and cannot limit food intake because of the fatigue,” and “It’s usually harder to cut the weight before menstruation as I feel like I’m bloated and full of water,” were two of the responses received. Five (31%) noted difficulties and food cravings during their period, “Difficult to lose water and my weight many times stagnates when I start my period” and “Gain weight before and during.” Another five (31%) observed no effect. However, none reported difficulties cutting weight immediately after their menses.

A total of four (25%) of the athletes adjusted their training intensity according to their cycle, “Yes, looser joints mean increased chances for dislocations and sprains” and “Yes I do, the reason why depends on my body. Sometimes I feel strong and can do more and other times I'm too weak and feel like I'm going to break something.” Contrary to this, a substantial majority of 12 (75%) said they did not, “No, we just soldier through" and " No, I don’t treat my period like it’s a break,” as well as, “I take some ibuprofen and get back to work. Very rarely, I have to sit out a few minutes because my cramps are very bad.” Another said, “No. Coach usually decides the intensity of training.”

Similarly, twelve (75%) respondents preferred competing straight after menstruation, three (19%) just before and one (5%) had no preference. Ten (62%) respondents used supplements to alleviate symptoms or maintain training loads during their cycle, “I take B12, vitamin D, iron, folic acid, and vitamin C” and “I need iron supplements. Irregular periods made me develop an iron deficiency,” plus, “Iron supplements! I have very low iron and have been prescribed iron tablets.”

Close to half, seven (44%) of the participants felt unable to discuss menstrual issues with their coach due to shame, perceived lack of understanding or being a taboo topic. Of the eight (50%) who could talk to their coach, half had a male coach and the other half had a female coach. Five (31%) participants were uncomfortable discussing the topic, three (18%) felt they wouldn't receive much support and four, a quarter of respondents. felt their coach would understand. Thus, many sub-themes emerged concerning the coach-athlete relationship; the first being a lack of understanding and limited action, “I tell him but he can’t do much” and “Since my coaches are older males, they don’t have the knowledge or understanding about the female menstrual cycle or how it makes me feel when I'm very fatigued or have back pain, tight muscles or heavy cycles. They mostly believe it’s due to lack of training or sleep.” “No, because I'm ashamed and shy mentioning this issue.” “Very uncomfortable, I feel as if he is not educated enough on the matter and will not be able to understand me.” Another said, “I think my coach would be supportive but would say for me to manage it how I feel best.”

Another sub-theme was perceived understanding and support, “As a male, he can be sympathetic (feel bad for me) but not empathetic (feel bad with me)” and “I think my coaches support me as a person but I haven't bothered discussing periods with them at all.” An important sub-theme was having good understanding and empathy, “Yes, the fact that my coach is a woman makes it feel more comfortable to talk about the cycle and how it makes me feel” and “Yes, my coach is my dad so I feel comfortable talking about it.” One more comment was, “Yes, my coach is a female and was also my training partner. She suffers from weight-cutting issues so anything I mention to her she understands and makes sure I do not make the same mistakes she did, so I am healthy and safe.”

Over a third (37%) of respondents did not manage their menstrual cycle while more than half (56%) emphasised diet and rest, “Nothing in particular. I try to rest as much as I can and fuel myself properly but this is not always possible” and “Eating clean helps, using supplements, staying hydrated, with mostly water, is a big thing and exercising regularly helps keep things moving.” Regarding the use of supplements, “I do take additional supplements, rest more, base my day on having more mental/physical rest to attend training and give my body more attention (such as teas, soups, going on walks).” Other sub-themes included the use of painkillers, “No, I only take painkillers when I have cramps.”

Hormonal birth control was also mentioned, “I got an IUD in the hope of helping stabilise my hormones and reduce cramping the week before and the week during my period. It seems to have helped because previously I would be unable to move during training from cramping pain. Now I rarely have any cramping or pain.”

Half of the participants did nothing or ignored their cycle while 25% used birth control, “I use birth control to help manage my irregular periods. It helps me keep them consistent” and “I’m using contraceptives.” One athlete used painkillers, while two adjusted their sessions, “I adjust sessions and take painkillers during the cycle.” Another athlete followed a holistic approach, “I do not take any contraceptives but do have a personal relationship with my gynaecologist who allows me to take a holistic approach to reduce my symptoms.” Half of the respondents did not use an app to track their cycle, six (37%) did and two (12%) tracked their cycle by other means. Eight (50%) of the participants felt unsupported, “I am left to myself to try to manage it. It does feel lonely, especially when severe cramping contributes to a loss and the coach is unsympathetic. Because my primary care physicians do not work with high-performance athletes regularly, I do not feel that they can provide adequate care for my needs.”

Some athletes (25%) turned to teammates, “Not really, I get closure sometimes from teammates, in that I'm not alone and others struggle with this too” and “Teammates give moral support and are nice to talk to when you’re having a hard time.” Two athletes were supported by medical professionals, “Yes, as part of our high-performance programme we have a team of doctors and support staff” and “My female gynaecologist is very attentive and does quarterly check-ins with me to see how my menstrual cycle is affecting my health, what works and what doesn’t.” One athlete was supported by their coach, “Yes. My coach and every female in my dojo.” Only two participants visited a specialist and followed their advice, “The gynaecologist I go to is very knowledgeable with holistic approaches such as acupuncture, teas, dietary needs and vitamins.” Two athletes visited but did not follow advice and over 60% never visited a specialist regarding training and their menstrual cycle, “Never … maybe I will.” Another said, “No. When I visited a gynaecologist because I was having my period twice a month, she prescribed birth control to me without providing any explanation of why this might be happening to me, even though she knew my background in sport. She also didn’t bother doing any tests.”

Knowledge and Support

Only three participants (19%) had heard of Relative Energy Deficiency in Sport (RED-S) before the study. Nonetheless, eight (50%) of the respondents found cutting weight difficult and three (19%) felt they had less energy, “I usually feel low energy and find it hard to do reach my maximum training level which results in a harder weight-cut process.” Two experienced more fatigue, “More tired,” “Tended to overeat” and “When losing weight during your period it feels impossible sometimes to move, making it even harder to lose the weight. My appetite increases too and that's an additional challenge to overcome, overeating.”

Another athlete linked dehydration to more cramps, “Doesn't impact me other than my stomach hurts more waiting to weigh in because I need water. And I don't drink anything in the last 4-6 hours and that makes my cramps worse.” One mentioned decreased motivation and commit-

ment, “I struggle to commit to the session and finish it or keep up an intensity of training to lose a specific amount of weight. Halfway through I decide ‘nope never mind’.”

After explaining RED-S and Low Energy Availability (LEA), a significant 14 (87%) of the participants believed female judoka were at risk, “Yes, most judoka have a bad relationship with food and often under fuel to make a specific weight category,” “Yes, we tend to lose more macro and micro vitamins and minerals and this could increase the chances of having deficiencies” and “Yes, especially because we do the weight-cutting sometimes to an enormous degree. Struggling yourself down 3-5 kilos every 4-8 weeks for competitions is unhealthy.” One participant said, “Yes for sure! When I was younger and competing in 52’s I didn’t have my period for a year due to low body weight and under fuelling. Judoka are at high risk and lots are uninformed, like me!” In agreement, “Yes because we train very hard and almost every day. Judo is a very physical sport so weights, running and judo practice are all part of the training and it can have a big impact on the body.”

Responses showed that 25% of participants felt their training did not need to be structured based on their menstrual cycle, “I don’t think it matters” and “I currently wouldn’t change anything training-wise during my cycle. I think it’s a case-by-case thing though, as some weeks I feel good and some weeks I feel bad, so I think it depends.” Three believed strength training and cardio should be decreased during menses, “When on my period I'd prefer gym and less cardio-centred workouts, with increased recovery time.” One participant emphasised increasing recovery and strength and decreasing contact training, “I think a mix of both strength training and recovery and lower intensities during menses because we can't control when it comes so it might come during competition and it would be better preparation.” Another participant noted strength training should be increased between cycles. Two participants felt coaches should be more knowledgeable to tailor sessions accordingly. The first said, “I have a poor understanding of the cycle myself, but from what I do know, I think that training should accommodate a female athlete's cycle phases. However, I don’t think there are enough coaches (female or especially male) who understand the menstrual cycle well enough to accommodate it.” The second said, “If it was possible, I wish coaches had more knowledge when it comes to this topic, to properly map out the training types according to different phases of your cycle. I do believe that the training cycle should be structured according to the athlete’s menstrual phase, in order to maximise overall performance while still giving importance to recovery. During the week of your period, recovery should be prioritised, whereas closer to ovulation should be used for strength training.”

A majority of 75% of participants said they would adapt their periodisation to their cycle if the competition calendar allowed. On a Likert scale of 1 to 5 (with 5 being very important), participants rated the importance of studying the menstrual cycle and performance at 4.06.

DISCUSSION

This study sought to explore the knowledge and experiences of elite female judoka concerning their menstrual cycles and how these cycles influence their athletic performance and competition results. The findings provide important insights into the challenges and understanding related to managing menstrual health, weight control and high-level athletic performance. Although the sample size was small, the Olympic tour is ‘elite’ and thus the participants selected to participate were targeted with relevance to the population.

Participants in the study were evenly distributed across various continental unions, with the Pan-American and European Judo Unions representing one-third of the sample. This demographic balance enhances the potential for generalisation of the study's findings across a diverse cohort of female judoka. Key themes that emerged included the physical and psychological challenges associated with high-performance judo, as well as difficulties in communication regarding menstrual health.

A notable concern was that nearly half of the respondents reported feeling unable to discuss menstrual issues with their coaches or any other individuals. This finding aligns with Brown et al. (2020), who emphasised the lack of awareness and dialogue surrounding menstrual symptoms among elite athletes, and with Bergström et al. (2023), who noted that although many athletes experienced menstrual cycle-related symptoms, only a quarter felt comfortable discussing these issues with their coaches.

The study found that approximately two-thirds of participants engaged in weight-cutting, averaging a loss of 3.13 kg before a competition. The participants also reported experiencing irregular menstrual cycles accompanied by symptoms such as fatigue, cramps, mood swings and heavy bleeding, all of which impaired their training significantly, both physically and mentally. These observations corroborate the findings of Meignié et al. (2021).

Physical symptoms, including pain, discomfort, fatigue and weakness, contributed to a reduction in training intensity. Psychologically, athletes reported heightened emotional sensitivity and diminished focus, which affected the quality of their training sessions adversely. Despite these challenges, only a quarter of the participants self-reported adjusting their training regimens to mitigate injury risks. Among those who did not modify their training, two predominant mindsets were observed: either a tendency to persevere despite discomfort or a lack of proactive engagement in training programmes.

Additionally, over two-thirds of participants acknowledged using various supplements, including prescribed iron, vitamin B12, vitamin D, folic acid and vitamin C, to support their training during menstruation. Coaches and clinicians need to recognise that female youth and adolescent athletes may be more susceptible to certain injury types, such

as concussion, musculoskeletal injuries and the Female Athlete Triad. This triad is characterised by low energy availability (with or without disordered eating), menstrual dysfunction, and low bone mineral density (Righi & Barroso, 2022).

Moreover, as indicated by Aitkenhead et al. (2023), elevated estrogen levels during specific phases of the menstrual cycle can influence energy metabolism and muscle glycogen storage positively which may benefit high-intensity, short-duration exercises. While the menstrual cycle did not affect the physiological responses and training variables of well-trained and elite female athletes significantly, individual fluctuations were observed. Therefore, it is recommended that athletes monitor their menstrual cycles to optimise training and enhance performance.

This study revealed a significant finding: most participants were unaware of RED-S (Relative Energy Deficiency in Sport) or LEA (Low Energy Availability). Nevertheless, half of the participants reported experiencing symptoms indicative of these conditions. Upon receiving an explanation of these syndromes, they recognised that female judoka who engaged in weight-cutting faced a heightened risk. Currently, the understanding of the potential risks associated with RED-S and its link to various health issues remains low. RED-S arises from an imbalance between energy intake and expenditure, leading to potential disruptions in several physiological functions, including basal metabolism, bone density, menstrual cycles, cardiovascular health, and immune system function. The normalisation of amenorrhea and the reluctance of athletes to seek assistance for this issue, a well-documented consequence of RED-S, further exacerbates these risks. Research by Verhoef et al. (2021), Coelho et al. (2021), Vogel et al. (2023), and Leal Cortes et al. (2021) indicates that athletes experiencing menstrual disorders, such as primary and secondary amenorrhea or dysmenorrhea, are more likely to develop RED-S. This condition can lead to serious health problems and a decline in athletic performance.

The socio-cultural context surrounding judo often legitimises weight-cutting, despite its inherent risks. Participants have noted that coaches and peers frequently endorse this practice as a competitive strategy, which may undermine skill and strength development while simultaneously increasing the risk of injuries, including those related to mental health. This practice is particularly prevalent in lower weight categories. A study by Itaka et al. (2022) found that during the post-menstrual period, lightweight judoka exhibited higher scores on the MDQ for autonomic nervous system incoordination, poor concentration, water retention, and other negative effects when compared to their middle and heavyweight counterparts. Notably, there were no significant differences observed in other parameters across the weight categories during the pre-menstrual, menstrual or post-menstrual phases.

Study Implications

The findings highlight that while many elite female judoka, despite understanding the negative impact of weight-cutting on menstrual cycles, continue to participate in this practice, with an average weight loss of 3.13 kg. This normalisation of weight-cutting reveals a critical area for intervention. Additionally, the lack of awareness and support regarding Relative Energy Deficiency in Sport indicates an urgent need for improved education and support systems to assist athletes in managing their menstrual and overall health more effectively. The study shows that while most elite female judoka recognise the potential effects of rigorous training, particularly related to weight-cutting during their menstrual cycles, a significant number do not take proactive steps to address this and report inadequate support structures. Participants rated the importance of the study's topic as significant (4.06).

CONCLUSION

This study illustrated the intricate relationship between the menstrual cycle, weight management and performance in elite female judoka, revealing significant challenges many athletes face, experiencing performance-affecting symptoms yet lacking adequate support. Consistent with earlier research (Brown et al., 2020; Bergström et al., 2023), athletes reported fatigue, cramps and mood disturbances but rarely adjusted training intensity, reinforcing the findings of Itaka et al. (2022) regarding the challenges of weight-cutting, particularly among lighter judoka. This adds to the literature and exposes a widespread lack of awareness of Relative Energy Deficiency in Sport (RED-S) (Verhoef et al., 2021). The data underscores the necessity for improved education, tailored training programmes and open communication channels between athletes and coaches to mitigate the physical and psychological impacts of the menstrual cycle on performance (Meignié et al., 2021). By increasing awareness and providing tailored support, potentially negative impacts on performance can be mitigated, enhancing overall athlete wellbeing and success. Future research should explore coaches' knowledge and perceptions of menstrual health and develop evidence-based strategies to support female athletes. Implementing the recommended actions could help create a more supportive and informed sporting environment, enabling athletes to achieve their full potential.

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A Performance Profile of a Top Bosnian Herzegovinian Judo Athlete Larisa Čerić

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Abstract: *A significant number of women have made an invaluable contribution to the promotion and development of judo worldwide through their achievements. One such athlete is elite competitor Larisa Čerić, a three-time Olympian and a multiple medallist in world, European, Mediterranean, university, Balkan, and national championships. She has left a profound mark on Bosnian-Herzegovinian judo.*

The aim of this study is to determine the performance profile of Bosnia and Herzegovina's most successful female judoka, Larisa Čerić. A single-subject study was conducted on Larisa Čerić, analysing her technical and tactical performances across various competition levels in two fight segments: victories (n=132) and defeats (n=111). The results indicate that her victories were predominantly achieved through techniques from the katame-waza group, followed by techniques from the nage-waza group. Within the subgroups of techniques, she excelled in yoko-sutemi-waza, osaekomi-waza and shime-waza, while the most frequently awarded penalties were for false attacks and stepping out of the contest area. Her most effective technique was soto-makikomi. Among her losses, she was most frequently beaten using techniques from the nage-waza group, primarily ashi-waza and yoko-sutemi-waza. In the katame-waza group, she was most often held down with osae-komi-waza. The most commonly awarded penalties in her defeats were for non-combativity, false attack, stepping outside the contest area and defensive posture. The techniques that most frequently led to her losses were sasae-tsurikomi-ashi, uchi-mata and o-soto-gari.

Given that Larisa Čerić comes from a small judo federation, her results represent a significant legacy for future generations of judoka. This study highlights the importance of analysing the performances of elite female competitors, of whom there have been many.

Keywords: *combat sport, female, analysis, efficiency, excellence, legacy*

The Legacy of Prof. Dr Jigoro Kano (The Committee for the Commemoration of the 150th Anniversary of the Birth of Jigoro Kano, 2020) is immeasurable. After founding the martial art and later the sport known as judo ('the gentle way') in 1882, his messages and practical contributions have remained relevant in all aspects of both sporting lives and life in general. The establishment of judo as both a sport and a philosophy is based on two key concepts: *Seiryoku Zenyo* (maximum efficiency with minimum effort) and *Jita Kyoei* (mutual benefit and welfare for society). Judo is not merely a martial art or a sport, it is a path of self-improvement and personal contribution to society, providing tools for the development of better individuals and harmonious communities.These principles elevate judo beyond the realm of sport, transforming it into a comprehensive life philosophy. Kano believed that judo should be accessible to everyone, regardless of gender, age or social status. He was a visionary who recognised the importance of including women in sport (Callan, 2021; International Judo Federation, 2020), not only as a form of physical activity but also as a means of empowerment and personal development. He argued that judo was not reserved exclusively for men but that women could also benefit from its principles for their physical and mental advancement.

In 1893, Kano invited women to train in judo at the Kodokan for the first time, a radical step at a time when women faced severe restrictions in public and physical life. He believed in empowering women not only as practitioners but also as instructors of judo. One of his most significant decisions was appointing Ms Keiko Fukuda, his student, as a leading judo instructor. Fukuda later became the first woman to wear the 10th dan, the highest rank

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in judo, symbolising the fight for gender equality in sport. Jigoro Kano promoted judo as a means of preserving women's health, strengthening the body and spirit, and preparing for everyday life. His approach helped women develop self-confidence and independence, which was of immense importance in the patriarchal society of the time (Mizoguchi, 2024). Through judo, Kano advocated for women's rights in terms of education, physical activity and personal development, equal to those of men. His philosophy of 'mutual benefit' extended to the field of gender equality; he believed that society could only progress if all its members, including women, had equal opportunities for development.

At the 1988 Seoul Olympic Games, women's judo was introduced as a demonstration sport and since the 1992 Barcelona Olympic Games, women have participated in the judo competition as an official Olympic discipline on equal footing with men (Allan & Kiss, 2024). However, one must not overlook the significance of the first Women's Judo World Championship, held in 1980 in New York, which represented a pivotal moment in the global expansion of women's judo (Callan & Callan-Spenn, 2024).

Today, women constitute a substantial part of the judo community and numerous international programmes are dedicated to promoting judo among women. Judo has become a powerful tool for women's empowerment across various cultures and social settings worldwide. Judo serves as a model of equality and equity between men and women, yet the path to achieving this equality has been long and challenging. Women in judo had to fight persistently for the recognition of their rights, challenging established norms and asserting their place in a traditionally male-dominated sport. Women's judo is the result of this struggle for equality and equal rights within the judo community. Today, female champions stand on an equal footing with their male counterparts, representing their nations on the international stage proudly.

Judo is now one of the most popular martial arts in the world, practised by millions across more than 200 countries. Jigoro Kano left behind more than just a sport; he established universal values that form the essence of judo: respect, discipline, mutual assistance and continuous self-improvement. One of the countries where judo has developed significantly is Bosnia and Herzegovina. The judo federation of Bosnia and Herzegovina became a full member of the European Judo Union (EJU) in 1993 and was later accepted into the global judo family (IJF) in September of that year in Hamilton, Canada. Many athletes have contributed to the growth of judo in Bosnia and Herzegovina, winning numerous medals at various levels of competition.

Among them, Davor Vlaškovec stands out as a bronze medallist at the 1995 European Championships in Birmingham, while Amel Mekić claimed a gold medal at the 2011 European Championships in Istanbul.

A particularly prominent figure in Bosnian judo is Larisa Čerić (IJF, 2025), an Olympian multiple times and a decorated world and European medallist. Her achievements warrant a dedicated article analysing her performances. Čerić represented Bosnia and Herzegovina at three Olympic Games: Rio 2016, Tokyo 2021 and Paris 2024 where she secured a seventh-place finish. Larisa Čerić is the most accomplished judoka in Bosnia and Herzegovina and the most successful athlete in the country's history. Among her most notable achievements are: 1st place at the 2009 Junior World Championships, 1st place at the 2009 and 2013 Mediterranean Games, 1st place at the 2009 and 2012 European U23 Championships, 2nd place at the 2010 European U23 Championships, 1st place at the European University Championships, 1st place at the 2014 and 2017 European Championships, 2nd place in the Open category at the 2017 World Championships, 2nd place at the 2018 European Championships, 3rd place at the 2018 World Championships, 2nd place at the 2019 European Games, and 3rd place at the 2022 Mediterranean Games.

Judo competition analyses from a technical-tactical perspective have frequently been the subject of research. However, studies on individual performance profiles of competitors remain rare, particularly for female judoka. Adam and Majdan (2011) examined the individual technical-tactical profile of Joanna Majdan, the first Polish judoka to achieve significant success in international tournaments. She won a bronze medal in Vienna 1984 year, finished 5th at the 1982 World Championships, claimed three medals at individual European Championships (1986, 1988, 1989) and became the world universities champion in 1986. Additionally, she secured bronze medals at the world universities championships three times (1984, 1988, 1990). She was crowned Polish national champion nine times. A total of 202 contests from 55 judo competitions between 1988 and 1993 were analysed. During this period, Majdan successfully executed 232 attacks and earned 1,486 points from judges. She utilised 22 judo techniques effectively, with her favourite being *seoi-nage*, which she executed proficiently using both her right and left side.

Regarding male judoka, several studies have focused on analysing individual performance profiles. Ahmedov et al. (2024) conducted a technical-tactical analysis of Davlat Bobonov, a bronze medallist in judo at the Tokyo Olympic Games. A specialised video analysis of 125 official judo contests was performed, focusing on the relationship between standing techniques (*tachi-waza*) and groundwork techniques (*ne-waza*), as well as the efficiency of standing combat and ground control techniques. The results revealed that 24.8% of Bobonov's effective techniques belonged to *katame-waza*, while 75.2% were *ne-waza*. He demonstrated high efficiency in executing *koshi-waza* (hip throwing techniques), *sutemi-waza* (sacrifice techniques), *ashi-waza* (leg techniques), and *te-waza* (hand techniques).

Adam, Smaruj, and Pujszo (2012) analysed the technical and tactical characteristics of four elite judo competitors based on their individual indices: Rishod Sobirov (UZB, -60 kg), Jae-Bum Kim (KOR, -81 kg), Ilias Iliadis (GRE, -90 kg) and Teddy Riner (FRA, +100 kg). The competitors exhibited significant differences in the analysed indices. In 2011, Jae-Bum Kim attempted attacks most frequently (every 15.5 seconds), whereas Ilias Iliadis had the lowest attack frequency that year (every 47 seconds). Teddy Riner executed successful attacks most frequently in 2011 (every 112.5 seconds), while Jae-Bum Kim, in 2010, rarely performed successful attacks (every 373.2 seconds). When comparing the attack frequency at the 2010 and 2011 world championships, Sobirov and Kim improved their attack rates, whereas Iliadis and Riner showed a decrease. The frequency of successful attacks improved for Sobirov, Kim and Riner, while Iliadis' results deteriorated. Rishod Sobirov demonstrated the greatest range of techniques used, whereas Riner had the smallest. Jae-Bum Kim exhibited the highest attack intensity, while Iliadis had the lowest. Teddy Riner and Ilias Iliadis recorded the highest effectiveness index values, whereas Jae-Bum Kim and Rishod Sobirov had the lowest values for that index. However, Teddy Riner had the highest efficiency index, while Jae-Bum Kim's opponents received penalty points most frequently.

Adam and Wolska (2016) analysed the effectiveness of offensive and defensive actions during top-ranked judo tournaments to develop an individual technical-tactical profile of Teddy Riner based on general performance indicators. Their study examined the technical elements Riner applied during the Olympic Games and world championships from 2007 to 2014. Throughout all analysed contests, Riner attacked more frequently than his opponents and demonstrated 100% defensive efficiency; he never allowed his opponents to execute any technique successfully. The range of techniques he used varied across different contests. The analysis of Teddy Riner's technical and tactical preparation highlights his increasing dominance over opponents in successive world championships. The lowest index values were recorded during the Olympic Games, which could be attributed to the presence of the strongest competitors at this prestigious event and the greater pressure associated with its significance.

Adam (2013) investigated the technical-tactical preparation profile and the techniques that enabled Pawel Nastula to achieve high efficiency and success in elite competitions. The study analysed 98 contests from 1991 to 1992, across 24 tournaments. During this period, Nastula executed 145 judo attacks effectively and earned 1,022 points based on judges' evaluations. The applied research methods enabled the identification of his dominant techniques and the values of individual technical-tactical preparation indices. Paweł Nastula utilised 25 judo techniques effectively, with *seoi-nage* being his preferred technique. He also employed techniques from *ashi-waza* (leg techniques) and *te-waza* (hand techniques) groups and demonstrated exceptional efficiency in *katame-waza* (ground control techniques). When executing throws, he utilised both the right and left sides of his body, throwing in four directions. Point deductions resulted solely from referee penalties rather than attacks by his opponents.

Adam, Smaruj, and Laskowski (2014) investigated the technical-tactical profile of one of the greatest judoka in the history of the sport, Waldemar Legień, a two-time Olympic gold medallist in different weight categories (78 kg and 86 kg). The study analysed his career from 1991 to 1992, during which he participated in 24 tournaments, both domestically and internationally. His remarkable winning streak can be explained by his ability to employ techniques from all major throwing groups. His extensive repertoire of 19 different techniques, including throws and holds, confirms his technical excellence. The study suggests that one of the key characteristics of Legień as an elite judoka was his technical and tactical versatility.

Analysing athletes' performance is crucial for understanding the factors contributing to their success as well as their failures in competitions. Therefore, there is a need for a detailed examination of each athlete's individual performance profile to enhance their training and strategies, ultimately aiming for improved results.The objective of this study is to analyse the performance profile of Bosnia and Herzegovina's most accomplished female judoka, Larisa Čerić.

METHODS

Sample of respondents and variables

The sample of respondents for this study is the elite judoka Larisa Čerić during the period from 2009 to 2025, covering 92 competitions, where a total of (n=243) contests were analysed, consisting of (n=132) victories and (n=111) defeats.

The analysed variables for this study include:

- Attacking efficiency index of nage-waza and *katame-waza* judo techniques in victories and defeats,
- Attacking efficiency index of judo technique sub-groups in victories and defeats,
- Penalties received in victories and defeats,
- Attacking efficiency index of individual throwing techniques and groundwork techniques in victories and defeats.

Procedure

The data was collected through notation analysis of available video recordings of Larisa Čerić's contests, accessible on (IJF, 2016; IJF, 2021; IJF, 2024), IpponTV, Judobase, JudoInside, and internet search engines. The video analysis was conducted by two observers with many years of domestic and international experience as competitors, referees and academic

professionals, working under identical conditions. All actions of the competitor and referees were recorded in pre-prepared data sheets. The observers were tasked with registering the executed throwing or groundwork techniques, as well as the referee decisions displayed on the scoreboard. To ensure the accuracy of the performed techniques during the analysed contests, the following sources were used (Daigo, 2005; Inokuma and Sato, 1986; Kano, 1986).

Statistical analysis

The attack efficiency index (AEI) for each throwing and grappling technique performed successfully was calculated with the help of formula (1) by Adam, Smuraj, & Pujszo (2016).

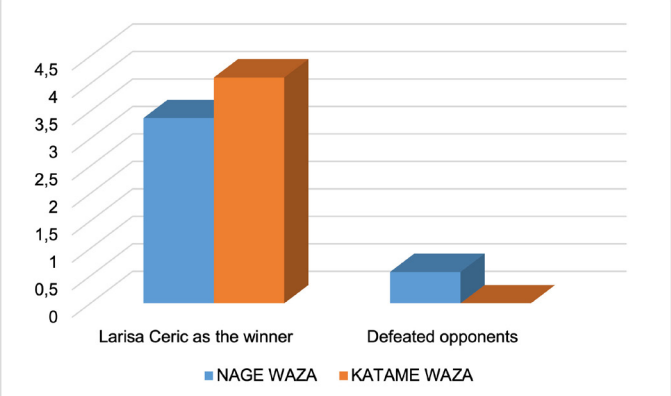
$$AEI = 5 \times M + 7 \times M + 10 \times M / n \qquad (1)$$

In which case:
5 points = yuko
7 points = waza-ari
10 points = ippon
M = the number of effective attacks
n = the number of analysed fights.

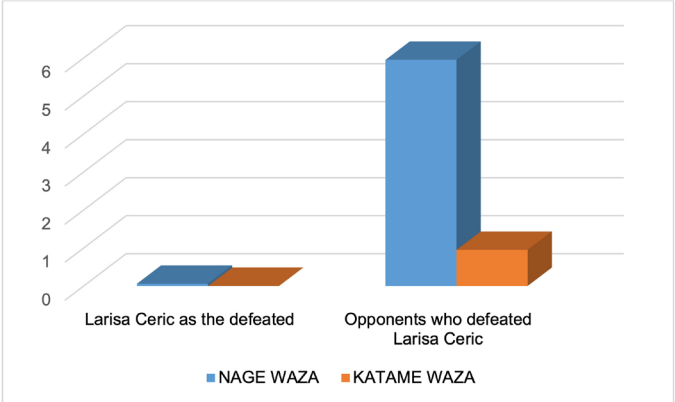
The penalties received by the competitors during victories and defeats are presented graphically in percentage values.

RESULTS

Analysing the contests in which Larisa Čerić won (Graph 1), the results demonstrated her dominance in *katame-waza*, with an Attack Efficiency Index (AEI) of 4.11, and a slightly lower AEI of 3.37 for nage-waza throwing techniques. Among her opponents who lost the matches, the AEI for *katame-waza* was very low (AEI = 0.57) because they threw her eight times for waza-ari scores, while they did not apply any *katame-waza* techniques at all (AEI = 0.00). In the contests that Larisa Čerić lost (Graph 2), she managed to execute only one throwing technique, with an AEI of 0.06, while she was unable to apply any *katame-waza* techniques (AEI = 0.00). Opponents who defeated her had a very high Attack Efficiency Index (AEI = 5.95), while their AEI for *katame-waza* techniques was 0.95.



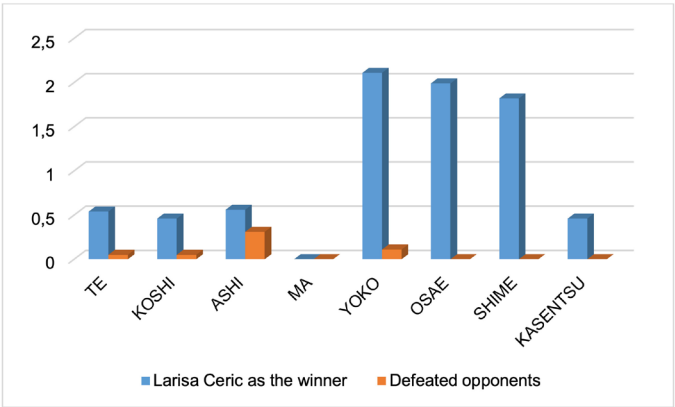
Graph 1. Attack Efficiency Index (AEI) of nage-waza and *katame-waza* in Larisa Čerić victories.



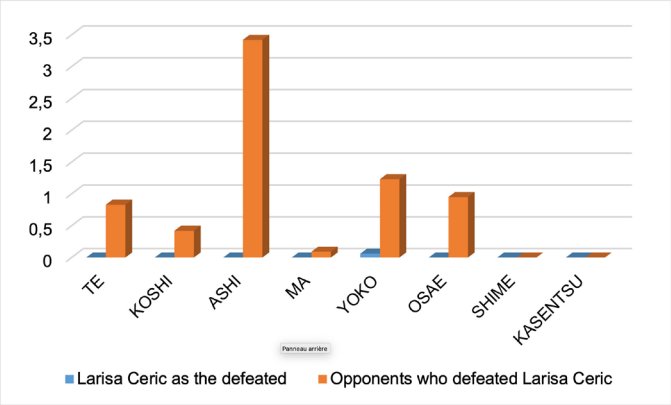
Graph 2. Attack Efficiency Index (AEI) of nage-waza nd *katame-waza* in Larisa Čerić defeats.

Observing the results obtained by Larisa Čerić in the contests she won (Graph 3), her dominance is clearly evident in the attack efficiency index of side-sacrifice throwing techniques *yoko-sutemi-waza* (AEI = 2.11), control techniques – *osaekomi-waza* (AEI = 1.99), choking techniques – *shime-waza* (AEI = 1.82), leg techniques – *ashi-waza* (AEI = 0.56), hand techniques – *te-waza* (AEI = 0.54), and the same attack efficiency index values for side hip techniques *koshi-waza* and joint locks *kansetsu-waza* (AEI = 0.46). Her defeated opponents managed to achieve the highest number of throws using leg-throwing techniques – *ashi-waza* (AEI = 0.31) and the same attack efficiency index values (AEI = 0.05) for hand techniques *te-waza* and side hip techniques koshi-waza. However, there were no successful backward sacrifice throws *ma-sutemi-waza*, control techniques, choking techniques or joint locks (AEI = 0.00).

On the other hand, Larisa Čerić's results in the contests she lost (Graph 4) show that she was unable to execute any of the eight sub-groups of judo techniques (AEI = 0.00). The opponents who defeated her were most successful in executing throws from leg techniques, side-sacrifice throws, holding techniques, hand throws and side hip throws. However, they were unable to apply choking techniques or joint locks on Larisa Čerić.

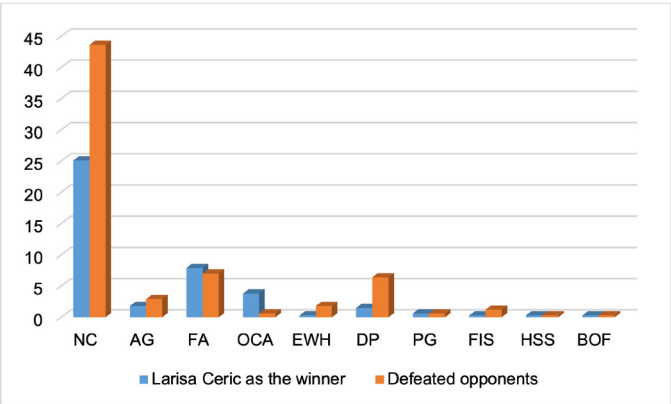


Graph 3. Attack Efficiency Index (AEI) of judo technique sub-groups in Larisa Čerić's victories.



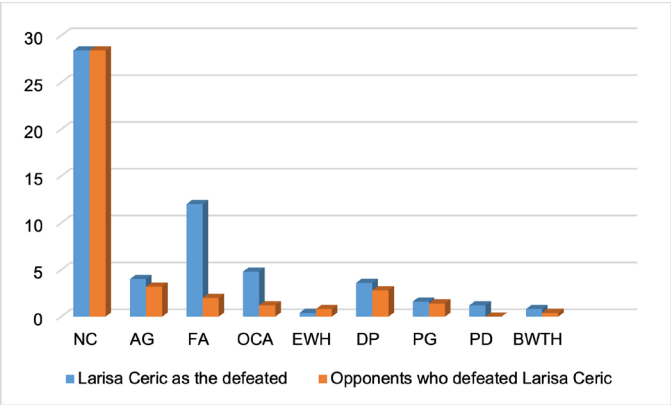
Graph 4. Attack Efficiency Index (AEI) of judo technique sub-groups in Larisa Čerić's defeats.

Analysing the penalties during the contests won by Larisa Čerić (Graph 5), it is evident that her opponents received most penalties for passivity, defensive posture, false attack and avoiding the grip. In the contests she lost (Graph 6), both Larisa Čerić and her opponents had the same number of passivity penalties, while Larisa Cerić had a higher number of false attack, stepping out of the contest area, avoiding the grip and defensive posture penalties.



Graph 5. Percentage values of received penalties in Larisa Čerić's victories

Legends: NC – Non-combativity, AG - Avoid grip, FA - False attack, OCA - Outside contest area, EWH - Ecsape with head, DP - Defansive posture, PG - Pistol grip, FIS - Fingers in sleave, HSS - Hold same side and BOF - Bend opponent's fingers



Graph 6. Percentage values of received penalties in Larisa Čerić's defeats.

Legends: NC – Non-combativity, AG - Avoid grip, FA - False attack, OCA - Outside contest area, EWH - Ecsape with head, DP - Defansive posture, PG - Pistol grip, PD - Pull down, BWTH - Block with two hands

In the contests she won (Table 1), the most successful technique applied by Larisa Čerić was *soto-makikomi* (AEI = 1.91), followed by seven techniques from the *katame-waza* group. Her opponents, in their defeats, most frequently used the techniques *tani-otoshi* and *o-soto-otoshi*. However, in the contests that Larisa Čerić lost (Table 1), she executed only one throwing technique successfully, *harai-makikomi*. The opponents who defeated her most effectively applied leg techniques, with the most effective ones being *sasae-tsurikomi-ashi*, *uchi-mata* and *o-soto-gari*.

Table 1. Attacking Efficiency Index (AEI) of individual throwing techniques and grappling techniques of Larisa Čerić and her opponents during their wins and losses.

Larisa Čerić as the winner		Defeated opponents		Larisa Čerić as the defeated		Opponents who defeated Larisa Čerić	
Tech.	AEI	Tech.	AEI	Tech.	AEI	Techn.	AEI
SMK	1.91	TNO	0.11	HRM	0.06	STA	0.83
OEJ	0.91	OSO	0.11			UMA	0.67
KHJ	0.83	HRG	0.05			OSG	0.51
KEG	0.62	UMA	0.05			SMK	0.45
UKG	0.52	OSG	0.05			SOT	0.37
WAK	0.30	KSK	0.05			YSG	0.37
KKS	0.28	TOS	0.05			KSH	0.31
SOT	0.27	SMK	0.05			AGU	0.31
YSG	0.26					UWA	0.31
KKE	0.18					HIZ	0.28
HRM	0.15					OUG	0.25
STA	0.15					STG	0.24
KSH	0.13					TOS	0.22
ISN	0.11					TNO	0.19
TOS	0.11					KUG	0.18
OSG	0.09					HRG	0.18
OUG	0.09					KSG	0.15
JGT	0.08					HRM	0.13
STG	0.08					SOO	0.09
UGO	0.08					TNG	0.09
UMA	0.08					KEG	0.09
KTJ	0.08					ISN	0.09
UGR	0.08					YGA	0.09
KUG	0.05					OSO	0.09
UMK	0.05					HGG	0.09
SOO	0.05					URG	0.06
KSK	0.05					KKS	0.06
HRG	0.05					KKE	0.06
						SON	0.06
						HGE	0.06
						YGU	0.06

Legends: SMK Soto-makikomi, OEJ Okuri-eri- jime, KHJ Kataha-jime, KEG Kesa-gatame, UKG Ushiro-kesa-gatame, WAK Waki-gatame, KKS Kuzure-kami-shiho-gatame, SOT Sumi-otoshi, YSG Yoko-shiho-gatame, KKE Kuzure-kesa-gatame, HRM Harai-makikomi, STA Sasae-tsurikomi-ashi, KSH Kami-shiho-gatame, ISN Ippon-seoi-nage, TOS Tai-otoshi, OSG O-soto- gari, OUG O-uchi- gari, JGT Juji-gatame, STG Sode- tsurikomi-goshi, UGO Uki-goshi, UMA Uchi-mata, KTJ Katate-jime, UGR Ude-garami, KUG Ko-uchi-gari, UMK Uchi-makikomi, SOO Seoi-otoshi, KSK Ko-soto- gake, HRG Harai-goshi, TNO Tani-otoshi, OSO O-soto-otoshi, AGU Ashi-guruma, UWA Uki-waza, HIZ Hiza-guruma, KSG - Ko soto gari, TNG Tomoe-nage, YGA Yoko-gake, HGG Hane-goshi-gashi, URG Ura-gatame, SON Seoi-nage, HGE Harai-goshi-gaeshi and YGU Yoko-guruma.

DISCUSSION

The objective of this study, which analysed the performance profile of Bosnia and Herzegovina's top judoka, Larisa Čerić, has been fully achieved. Through systematic analysis, her physical, technical, tactical and characteristics were identified, enabling an objective assessment of her abilities in comparison to her opponents (McGary, O'Donoghue, & Sampaio, 2013). These findings are crucial for monitoring progress, identifying strengths and weaknesses, and optimising the training process to achieve maximum athletic efficiency. In this way, the fundamental principle of judo—'maximum efficiency with minimal effort' - has been realised (Kano, 1986).

Victory and defeat are integral aspects of sport, including judo (Willingham, 2007), and their impact carries profound psychological, emotional and social significance. Insights gained from these aspects provide a clear understanding of the performance profiles of both male and female competitors.

The characteristics of winners include the achievement of predetermined goals, whether winning a medal, a title or an individual contest. Their success is the result of effort, dedication and the effective application of various strategies. Victory brings a sense of pride, validates one's abilities and often strengthens self-confidence. Additionally, it garners fame, public recognition and acknowledgment from audiences, the media and fellow athletes. Winners serve as role models for younger generations and as an inspiration for future judoka. Furthermore, success in competition opens doors to participation at higher levels and allows for continued skill development and athletic career progression.

On the other hand, defeat signifies the failure to achieve a desired goal, potentially leading to feelings of frustration, sadness and reduced self-confidence. However, losing can also be a powerful motivator for correcting mistakes, learning and improving (Kajmovic, 2021). Many athletes consider their greatest lessons to have come from their defeats, making such experiences invaluable. Defeat can leave deep emotional consequences, though, particularly when victory is expected or when the competition outcome is unexpected.

The results of Larisa Cerić indicate that her win-loss ratio stands at 54.3% victories and 45.7% defeats. When her statistics are compared to those of Olympic champions, it is evident that they achieved significantly better results: Paris 2024 – Beatriz Souza (71.4% wins, 28.6% losses), Tokyo 2021 – Akira Sone (87.0% wins, 12.9% losses), Rio 2016 – Emilie Andéol (61.6% wins, 38.3% losses). Larisa Čerić participated in all these competitions. Furthermore, in comparison with the world champion at the Marrakech 2017 and Baku 2018 world championships — Sarah Asahina (83.5% wins, 16.5% losses) — where Cerić won silver and bronze medals, it is clear that all these competitors maintained more consistent results.

Larisa Čerić has achieved a respectable win-loss ratio; however, when compared to Olympic and world champions, her performance is somewhat lower. Interestingly, her ratio is closest to that of Emilie Andéol (Rio 2016), who recorded a 61.6% win rate, suggesting that even with a lower win percentage, reaching the top remains possible. Nevertheless, in order to compete for Olympic gold, it would be necessary to enhance efficiency and bring her performance closer to that of Akira Sone (87%) or Sarah Asahina (83.5%), both of whom dominated their respective competitions. It is important to emphasise that Larisa Čerić has won medals at world championships, demonstrating that she is capable of competing with the best. However, the key factors for securing a gold medal are likely to include maintaining consistency in achieving top-tier results, optimising physical preparedness and expanding the tactical repertoire in decisive contests.

In her victories, Larisa Čerić dominated through techniques from the *katame-waza* group primarily, indicating that groundwork techniques are her speciality. Her opponents were unable to apply any *katame-waza* techniques against her successfully. Conversely, in her defeats, she was predominantly overcome by techniques from the nage-waza group, while in *katame-waza*, she most frequently lost through techniques from the osae-komi-waza sub-group. Notably, she was never defeated by techniques from the *shime-waza* or *kansetsu-waza* groups.

The three sub-groups in which she excelled in victories were yoko-sutemi-waza, osae-komi-waza, and shime-waza, while other sub-groups remained at a relatively similar level.

In her defeats, Larisa Čerić's weaknesses were primarily in *ashi-waza*, *yoko-sutemi-waza* and *osae-komi-waza*. The main contributing factor was her balance position — her centre of gravity was shifted forward, combined with a defensive stance, passivity and insufficient movement. As a result, she was most frequently thrown using leg-based techniques. Regarding yoko-sutemi-waza, given that her opponents in the +78 kg category were significantly heavier than her, she was often thrown using techniques from this group.

An analysis of penalties in her victories reveals that her opponents most frequently received penalties for non-combativity, defensive posture and avoiding the grip, whereas she accumulated a slightly higher number of penalties for false attacks compared to her rivals. An interesting observation from the contests she lost is that both Larisa Čerić and her opponents received an equal number of penalties for non-combativity. This indicator can be explained by the characteristics of competitors in the +78 kg category, where static positioning, fast fatigue, lack of endurance and high energy expenditure play a significant role (Franchini et al., 2011; Miarka et al., 2016; Sterkowicz-Przybycień & Sterkowicz, 2009). Additionally, Larisa Čerić received a higher number of penalties for false attacks, exiting the contest area, defensive posture and avoiding the grip. A possible

explanation for these patterns is her inability to overturn an unfavourable score during contests, which led to increased energy expenditure and fatigue.

Larisa Čerić demonstrated exceptional tactical awareness in the contests she won, consistently placing her opponents in positions where she held the greatest advantage. Her victories in *katame-waza* confirm her judo intelligence, which is crucial for achieving technical and tactical superiority in groundwork. Her performances, particularly her tactical preparation, developed and analysed in collaboration with her coaching team, resulted in opponents being unable to execute *katame-waza* against her or defend effectively against her specialised groundwork techniques.

In her 111 defeats, her performances were not at an optimal level, which can be linked to frequent injuries and insufficient recovery. Another significant factor was the weight disparity between her and her opponents, which at times reached up to 20 kg. Larisa Čerić (IOC, 2024; IOC, 2021; IOC, 2016) weight at the Olympic Games: Rio 2016 – 106.7 kg, Tokyo 2021 – 101.7 kg and Paris 2024 – 99.7 kg. Weights of Olympic and world champions: Emilie Andéol (Rio 2016) – 98.9 kg, Akira Sone (Tokyo 2021) – 105.2 kg and Beatriz Souza (Paris 2024) – 135.2 kg. Sarah Asahina (World Champion 2017 and 2018) – 123.0 kg and 125.0 kg. Through three Olympic cycles, Larisa Čerić reduced her weight progressively, demonstrating her commitment to improving physical fitness and competitive performance. Her best result, a seventh-place finish at the Paris 2024 Olympic Games, was achieved when she had the lowest weight compared to her previous two appearances, in which she was eliminated in the first and second rounds, respectively. It could be stated that weight reduction had both positive and negative consequences. On one hand, it resulted in greater mobility and speed, while on the other hand, it may have led to a lower level of strength compared to physically dominant opponents (Franchini et al., 2005; Santos et al., 2019).

This data highlights different approaches to combat strategy. While some competitors rely on strength and weight, others prioritise agility and technique. Although greater weight often provides an advantage in the +78 kg category, it is not the decisive factor.

In her victories, Larisa Čerić utilised a repertoire of 28 different techniques, with her most effective throwing technique in *tachi-waza* being soto-makikomi. For comparison, the most effective throwing techniques of Olympic champions were: Paris 2024 – Beatriz Souza (harai-goshi), Tokyo 2021 – Akira Sone (o-uchi-gari) and Rio 2016 – Emilie Andéol (harai-goshi). Additionally, the world champion (open category) in Marrakech 2017 and Baku 2018, Sarah Asahina, dominated with the harai-goshi technique. At these championships, Larisa Čerić won silver and bronze medals.

The committed execution of the *soto-makikomi* throw was her most successful technique, as it aligned with her morphological characteristics, motor abilities and fighting style. When executed correctly, the opponent rarely manages to avoid the fall or transition into a counter-attack, as the technique engages the entire body rather than relying solely on arm or leg strength. Given that judoka in this category often have greater weight and a lower centre of gravity, the technique is performed through powerful body rotation, pulling the opponent close and controlling her arm, making any attempt at a counter-attack or defence significantly more difficult.

However, what stands out in her victories particularly are techniques from *katame-waza* (shime-waza, osae-komi-waza, and kansetsu-waza), which she executed with high efficiency.

During the contests she won, Larisa Čerić was most frequently thrown using *tani-otoshi* and osoto-otoshi, indicating certain issues with balance and movement quality. Additionally, this may have resulted due to limitations imposed by her opponents.

In the contests she lost, Larisa Čerić managed to execute only one throwing technique effectively: *harai-makikomi*. It is evident that each contest presents similar challenges and losses, even following excellent performances in previous contests, do not necessarily reflect weakness. Rather, they can be viewed as part of the process of gaining experience and refining skills with the aim of achieving optimal results. The reasons for her defeats can vary, ranging from physical or psychological exhaustion, insufficient recovery from injuries, physical superiority of her opponents, to the combat tactics that adversaries adapted to her style.

Throughout her 111 losses, Larisa Čerić was overcome by 31 different techniques from nage-waza and *katame-waza*, among which *sasae-tsurikomi-ashi*, uchi-mata, *o-soto-gari* and *soto-makikomi* stand out. This data indicates that despite losing 111 contests, she faced an exceptionally broad spectrum of strategies and fighting styles. Opponents employed a variety of techniques tailored to specific situations in which they proved most effective. Defeats by these techniques may suggest instances when Larisa Čerić encountered difficulties with balance and control of her centre of gravity. Additionally, a lack of control over the dynamics of the attack and an immediate inability to recognise the right moment for defensive action could have been key factors in those contests. However, this does not imply that her losses signify a serious decline in quality; in fact, they merely affirm the complexity of judo and the diversity of tactics and techniques available to opponents.

Considering that Larisa Čerić represents the judo federation of Bosnia and Herzegovina, which comprises around 4,000 registered competitors, and that she has faced numerous obstacles throughout her career (organisational, financial, health-related, etc.), her achievements gain further significance. When her successes are compared with

those of competitors who have won Olympic and world medals in the +78 kg category from federations such as Japan (123,838 registered competitors), France (540,000 registered competitors) and Brazil (162,302 registered competitors), it can be stated confidently that Larisa Cerić is an elite judoka, as she has overcome all challenges and established standards, demonstrating her excellence both as a competitor and as an individual.

CONCLUSION

Larisa Čerić has left an indelible mark on both Bosnian-Herzegovinian and global judo, showcasing exceptional technical and tactical proficiency alongside outstanding athletic achievements, despite the challenges she faced. Her performances and fight analyses highlight her specific strengths in *katame-waza*, while also revealing difficulties in match-ups against physically dominant opponents. In the context of international judo, her win-loss ratio confirms her competitiveness at the highest level but also indicates areas for improvement in consistency and strategic approach. It is particularly important to emphasise that studies like this are rare in judo, especially when it comes to female athletes. Performance analysis in women's sport is crucial, not only for understanding the factors of success and optimising training processes but also for highlighting the significance of women's sport in a global context. Since similar studies have predominantly focused on male competitors, research like this contributes to a deeper understanding of women's judo and can serve as a guideline for the development of future generations of female judoka. Larisa Čerić exemplifies an athlete who has transcended the limitations of a small judo federation, leaving a valuable legacy for future Bosnian-Herzegovinian judoka. Her career underscores the need for a more in-depth analysis of elite female competitors' performances to support their further development and ensure a more equitable representation in sports research.

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Weight Loss for Participants of the All Japan Technical College Judo Championships

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Abstract: *In this study, we attempted to identify the magnitude and methods of weight loss in the category of colleges of technology (KOSEN) by conducting a questionnaire survey on weight loss among athletes who participated in judo competitions at the All Japan Collegiate Schools of Technology Judo Championships. It was found that 16 out of 36 athletes (44.4%) lost weight within a week and 3 of them lost ≥ 5 % of their body weight. In addition, it was found that non-professionals such as "another judoka," "former judoka," "judo coach/sensei," and "parents" provided co-operation and guidance for the athletes' weight loss. In addition, most of the athletes in this study used gradual weight loss and increased exercise, while extreme weight loss methods such as fasting, diuretics and laxatives were never used. The results make it clear that, although most participants in the KOSEN category selected appropriate weight-loss methods overall, some selected methods involving health risks, such as rapid weight loss or multiple weight-loss attempts per year are not appropriate. It is necessary to develop educational programmes for weight loss for judo athletes in KOSEN in the future.*

Keywords: *judo; weight loss; fact-finding survey; KOSEN; Japan*

In judo competitions, weight categories are classified according to body weight to reduce inequalities in strength and power. In such weight-based events, changing weight classes is one of the strategies employed to win tournaments and it is common practice in competition to lose weight in order to compete in the desired weight category (Stavrinou et al., 2022).

An appropriate weight loss method is to lower body weight by gradually decreasing food intake and increasing daily physical activity at least two weeks prior to a competition (Artioli, 2010a). This method is less physically demanding without causing dehydration or excessive nutritional deficiencies. On the other hand, it has been reported that some athletes use methods of weight loss such as excessive food restriction for a few days or wearing clothing such as sauna suits to reduce body water content through perspiration. This practice is called rapid weight loss, defined as a weight loss of at least 5% of body weight within one week (Khodaee et al., 2015) and is considered to be physiologically and psychologically taxing (Franchini et al., 2012; Kim et al., 2018). For example, reported psychological effects include decreased memory, concentration and self-esteem, along with increased depression, anger and fatigue (Green et al., 2007). Other effects include acute cardiovascular dysfunction (Allen et al., 1977), immunosuppression (Kowatari et al., 2001), decreased bone density (Prouteau et al., 2006), impaired thermoregulation (Oppliger et al., 1996), temporary growth disturbances (Roemmich et al., 1997a), hormone imbalance (Roemmich et al., 1997b), increased risk of injury (Green et al., 2007), and increased risk of developing eating disorders (Escobar-Molina et al.,2015; Rouveix et al.,2007). In addition, Alderman et al. (2004) reported that in 1997 and 1998, three university student wrestlers died of heatstroke due to dehydration as a result of rapid weight loss.

As mentioned above, there are many findings related to weight loss in judo athletes. Most of these studies have been conducted with university students and above, and with junior and senior high school students. On the other hand, no findings in the category of KOSEN were found during the author's research. KOSEN are institutions of higher education that originated in Japan and were established in the late 1950s during a period of economic growth, when there was a strong demand for the training of engineers. KOSEN are neither high schools nor universities, but rather unique institutions in Japan in which students of high school age and first and second-year university students are mixed together. There are about 57 national, public and private KOSEN in Japan and Regional Technical College Championships are held once a year. Additionally, an All Japan Technical College Championship, with participants from the top schools and athletes of the Regional Technical College, is held later in the academic year. This competition between KOSEN is held once a year. The level of competition is diverse, with some

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students starting judo for the first time after entering a KOSEN and others who have been practising judo continuously since elementary school age. Also, it is unclear what methods the KOSEN category judo athletes use to lose weight before a competition.

As there have been no previous studies in this category, it is imperative to investigate the weight loss of judo athletes in order to improve the overall health of athletes, reduce the possibility of negative consequences related to weight loss, and educate instructors and athletes on how to manage weight for competition safely. Therefore, in this study we attempted to identify the magnitude and methods of weight loss among KOSEN students by conducting a questionnaire survey on weight loss among the judo athletes who participated in the All Japan Technical College Judo Championships.

METHODS

The participants were 36 male athletes who participated in the 2016 All Japan Technical College Judo Championship and responded to the questionnaire survey that they had experience of losing weight. The participants belonged to the following weight categories: 10 athletes in the -60 kg category, 4 athletes in the -66 kg category, 16 athletes in the -73 kg category, and 6 athletes in the -90 kg category. Table 1 shows the characteristics of the participants and Table 2 shows their competition levels. Regarding the age at which the athletes began practising judo and the age at which they first competed in judo competitions, some of the participants were 5 years old, the minimum age for this study, while others were 16 years old, the maximum. The competition levels of the athletes in this study were: 15 athletes (41.7%) were in the top four or higher at the regional level, 10 athletes (27.7%) were in the top four or higher at the state level, and none of them were in the top four or higher at the national level. 3 athletes (8.3%) had never participated at the regional level and 1 athlete (2.8%) had participated at an international level. In other words, the participants in this study were characterised by a mix of those who had never participated in the regional competitions and those who had participated in international competitions.

Table 1: Main characteristics of judo athletes

Variable	Mean ± SD	Range
Age (yr)	17.8 ± 1.3	15.0 - 20.0
Height (cm)	170.0 ± 5.4	156.0 - 183.0
Body Weight (kg)	71.7 ± 9.0	58.0 - 90.0
BMI (kg/m^2)	24.8 ± 2.8	19.8 - 31.2
Age began practicing judo (yr)	9.5 ± 3.3	5.0 - 16.0
Age began competing in judo (yr)	10.1 ± 3.1	5.0 - 16.0

Table 2: Levels of competition of the athletes

Competitive level	Never participated (%)	Less than top 4 (%)	Best 4 or more (%)
Regional	8.3	41.7	50.0
State	41.7	30.6	27.7
National	86.1	13.9	0.0
International	97.2	0.0	2.8

This study was conducted after obtaining approval from the Ethical Review Committee of the author's institution, and after providing sufficient explanation to the participants in advance and obtaining their consent to participate in accordance with the regulations. In the case of minors, the consent of their guardians was obtained. In the preparation and publication of the paper, the data of the participants was anonymised and their consent was obtained after explaining that individuals would not be identified.

A validated questionnaire (RWLQ: Rapid Weight Loss Questionnaire) was used to identify the magnitude and methods of weight loss (Artioli et al., 2010b). The RWLQ is a questionnaire survey used to investigate the athletes' methods of weight loss, consisting of two items: one concerning the subject himself/herself, such as age, gender and competitions in which he/she has participated, and the other concerning weight loss, such as whether or not he/she has lost weight and the specific methods used to lose weight. The English version of the questionnaire was translated into Japanese by an American whose native language is English. The purpose of this study was explained to the judo coach/*sensei* at the representative meeting the day before the competition and their consent to conduct the questionnaire was obtained. After that, questionnaires and consent forms regarding this research were distributed to the athletes through their judo coach/*sensei*. The deadline for responses was set at one week after the end of the competition. The responses from each player were submitted to the judo coach/*sensei*, who then sent them to the school where the representative of this research was affiliated.

The mean, standard deviation, maximum, and minimum values were calculated from descriptive statistics in order to grasp the condition of the questions regarding weight loss experience. Statistical analysis software SPSS Ver25.0 (IBM) was used for the analysis. To identify the distribution of the responses, we classified the responses into four or five categories and tabulated the frequencies, referring to a previous study by Artioli et al. (2010b). After tabulation, a histogram was created and compared for each category. For investigating the levels of competition of the athletes, the total number of each response was tabulated and compared.

The responses to the question regarding the participants who co-operated with and guided them through their weight loss and the question regarding the method of

weight loss were also tabulated in terms of frequency for each option. The frequencies were then compiled in a frequency statement table and compared. Microsoft Excel was used to analyse frequencies and number of participants to create histograms and tables.

RESULTS AND DISCUSSION

Table 3 shows the mean, standard deviation, maximum and minimum values of the athletes' answers to the question about their weight loss history. Figures 1(A), (B), (C), (D), (E) and (F) show the number of participants who lost weight for competition.

For the question "What is the most weight that you have cut to compete in your career?" the mean value was 4.2 kg, the minimum value was 1.0 kg and the maximum value was 12.0 kg. Looking at the distribution of responses (Figure 1-A), 8 athletes (22.2%) lost 2 kg or less, 16 athletes (44.4%) lost 2.1 to 4.9 kg, 9 athletes (25.0%) lost 5 to 9.9 kg, and 3 athletes (8.3%) lost 10 kg or more. When asked "How many times did you cut weight to compete last season," the mean was 1.8 times, the minimum was 0 and the maximum was 7 times. Looking at the distribution of responses (Figure 1-B), 7 athletes (19.4%) answered "0", 23 athletes (63.9%) answered "1-2", 4 athletes (11.1%) answered "3-5", and 2 athletes (5.6%) answered "6-10". The average weight loss was 2.3 kg, the minimum was 0 kg and the maximum was 7 kg. Looking at the distribution of responses (Figure 1-C), 4 athletes (11.1%) lost 0 kg, 18 athletes (50.2%) lost 2 kg or less, 9 athletes (25.0%) lost 2.1 to 4.9 kg, and 5 athletes (13.9%) lost 5 to 9.9 kg. When asked "Over how many days do you usually cut weight before competitions?" the mean was 15.0 days, the minimum was 4 days and the maximum was 31 days. Looking at the distribution of responses (Figure 1-D), 1 athlete (2.8%) answered <5 days, 15 athletes (41.7%) answered 5 to 7 days, 9 athletes (25.0%) answered 8 to 14 days, 3 athletes (8.3%) answered 15 to 21 days, and 8 athletes (22.2%) answered 22 to 31 days. The mean starting age for losing weight to compete was 15.3 years, the minimum was 12 years and the maximum was 18 years. Looking at the distribution of responses (Figure 1-E), 2 athletes (5.6%) were 12 years old, 2 athletes (5.6%) were 13 years old, 9 athletes (25.0%) were 14 years old, 6 athletes (16.7%) were 15 years old, 6 athletes (16.7%) were 16 years old, 9 athletes (25.0%) were 17 years old, and 2 athletes (5.6%) were 18 years old. When asked "how much weight do you usually regain in the week following a competition," the mean was 2.2 kg, the minimum was 0 kg, and the maximum was 5.0 kg. Looking at the distribution of responses (Figure 1-F), 3 athletes (8.3%) answered 0 kg, 20 athletes (55.6%) answered 2 kg or less, 12 athletes (33.3%) answered 2.1 to 4.9 kg, and 1 athlete (2.8%) answered 5 kg or more.

Table 3: Weight history reported by the judo athletes

Variable	Mean ± SD	Range
Most body weight lost (kg)	4.2 ± 2.4	1.0-12.0
No. weight reductions in the last year (times)	1.8 ± 1.6	0.0-7.0
Average weight usually lost (kg)	2.3 ± 1.6	0.0-7.0
No. days in which weight is usually lost (days)	15.0 ± 9.3	4.0-4.0
Age began cutting weight (yr)	15.3 ± 1.6	12.0-18.0
Weight usually regained in the week after competitions (kg)	2.2 ± 1.3	0.0-5.0

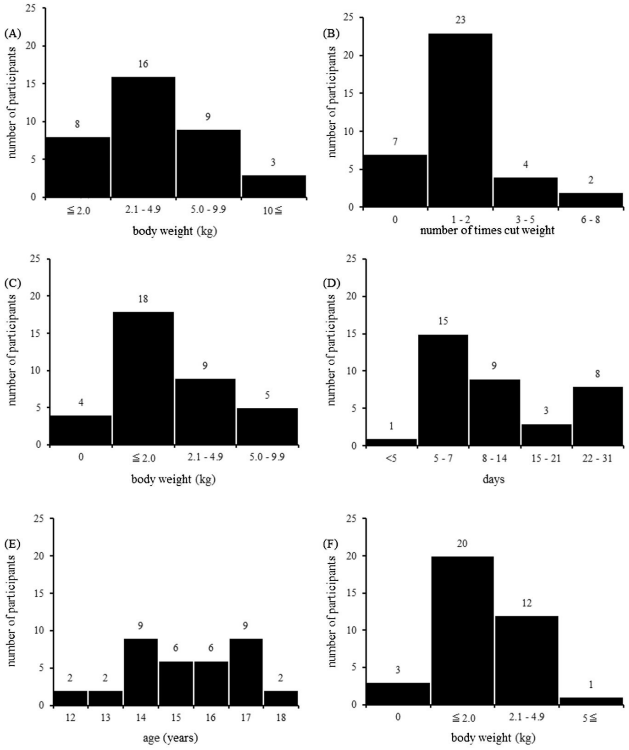

Figure 1: analysis of participant numbers for questions: (A) What is the most weight that you have cut to compete in your career? (B) How many times did you cut weight to compete last season (specify the year)? (C) How much weight do you usually cut before competitions? (D) In how many days do you usually cut weight for competitions? (E) At what age did you begin to cut weight for competitions? (F) How much weight do you usually regain in the week following a competition.

In a previous study by Khodaee et al. (2015), rapid weight loss was defined as "a weight loss of at least 5% of body weight in one week or less," and the present study revealed that 16 (44.4%) of the athletes lost weight within one week. When we looked at the percentage of weight loss for one week before the competition for 16 athletes; 3 athletes lost 1%, 2 athletes lost 2%, 7 athletes lost 3%, 2 athletes lost 4%, 3 athletes lost over 5% of body weight, indicating that 3 athletes fit in the rapid weight loss category. It was also clear that some of the athletes lost weight more than once a year (3 to 5 times or 6 to 8 times).

Such short-term weight loss, rapid weight loss, and weight loss multiple times per year are methods that can have significant physiological (e.g., hyperthermia, muscle weakness, cramps), psychological (increased risk of developing mental fatigue, headaches, eating disorders) and performance (reduced time to exhaustion, reduced myocardial efficiency) effects (Garrett et al. 2014). In summary, the actual state of weight loss in the KOSEN category has not been investigated to date and the situation has been unclear in many respects, but the revelation that some athletes participate in competitions with the aforementioned health risks should provide useful information for the organisers who run competitions in the KOSEN category, for staff who support the athletes and for the athletes themselves. In addition, the age at which some of the athletes started weight loss was as early as 12 years old (6th grade of elementary school). This may be due to an excessive win-at-all-costs mentality of the athletes, their parents and / or the staff who support them. In other words, in Japan, the excessive attitude of supremacy through victory has been recognised recently as a problem and the All Japan Judo Federation decided to abolish the All Japan Elementary School Judo Championship from 2022 (All Japan Judo Federation, online). Since this study was conducted in 2016, it is likely that the KOSEN category also included athletes who grew up in an organisation that emphasised winning as the primary goal of the athlete. It was also thought that athletes who had such experiences continued to use incorrect weight loss methods even when they reached high school or college age.

Table 4 shows the frequency analysis of the persons who are influential on the weight management behaviours reported by the judo athletes. The percentage of respondents who answered that they were “somewhat influential” or “very influential” by “another judoka”, “former judoka”, “judo coach/*sensei*” and / or “parents” was over 50%. However, only 8.3% of judo athletes said that they were influenced by a "physician" when they were losing weight.

Table 5 shows the frequency analysis of the weight loss methods used by the participants. All but one of the athletes answered that they "never" used or "do not use anymore" methods that were not considered appropriate for weight loss, such as laxatives, diuretics, diet pills, and vomiting by oneself. In addition, looking at the "always" responses of the athletes, "increased activity" was the most frequent response at 41.7%, followed by "gradual dieting" at 30.6% and "skipping one or two meals per day" at 22.2%.

Table 4: Frequency analysis of the persons who are influential on the weight management behaviours reported by the judo athletes

	Not Influential (%)	A Little Influential (%)	Unsure (%)	Somewhat Influential (%)	Very Influential (%)
Another judoka	22.0	0.0	16.7	41.7	19.4
Former judoka	33.3	0.0	13.9	33.3	19.4
Physician	66.7	5.6	27.8	0.0	0.0
Physical trainer	69.4	0.0	22.2	0.0	8.3
Judo coach/sensei	33.3	0.0	16.7	11.1	38.9
Parents	30.6	2.8	11.1	33.3	22.2
Dietitian	66.7	5.6	27.8	0.0	0.0

Table 5: Frequency analysis of the weight loss reported by judo athletes

Method	Always (%)	Sometimes (%)	Almost Never (%)	Never (%)	Do Not Use Anymore (%)
Gradual dieting	30.6	13.9	27.8	2.8	25.0
Skipping one or two meals	22.2	27.8	16.7	13.9	19.4
Fasting	5.6	2.8	22.2	8.3	61.1
Restricting fluids	16.7	33.3	27.8	2.8	19.4
Increased exercise	41.7	50.0	8.3	0.0	0.0
Heated training rooms	16.7	50.0	19.4	2.8	11.1
Sauna	16.7	30.6	22.2	2.8	27.8
Training with rubber/plastic suits	19.4	13.9	27.8	0.0	38.9
Using winter or plastic suits	0.0	11.1	36.1	0.0	52.8
Spitting	0.0	8.3	25.0	0.0	66.7
Laxatives	2.8	0.0	16.7	0.0	80.6
Diuretics	2.8	0.0	11.1	0.0	86.1
Diet pills	0.0	0.0	11.1	0.0	88.9
Vomiting	0.0	0.0	13.9	0.0	86.1

These results indicate that non-professionals such as "another judoka", "former judoka", "judo coach/*sensei*", and "parents" provided co-operation and guidance for weight loss among the athletes in this study, while physicians, physical trainers and dietitians, who have a high level of knowledge about weight loss from a medical perspective, provided little co-operation or guidance. The reasons for these results include the fact that the number of instructors with specialised knowledge such as physical trainers and dietitians for extra-curricular activities is limited due to economic considerations, and that most of the faculty members who serve as advisors for club activities are not experienced in the sport. Given the large number of athletes with various careers, as shown in Table 2 above, it is considered important to educate athletes and those who usually co-operate and provide guidance regarding weight loss in the KOSEN category.

On the other hand, it was found that most athletes in this study used appropriate methods such as gradual weight loss and increased exercise and that extreme weight loss methods such as fasting, diuretics and laxatives were never used, although there was no support from specialists. (Only one participant used diuretics and / or laxatives). The reason for these results may be that the athletes in this study already possessed understanding and skill in weight loss, since they were at a relatively high competitive level amongst KOSEN athletes. However, there is room for further discussion on this point, since the questionnaire was not administered to athletes at a lower level of competition, such as those who only competed at Regional Technical College Championships. Finally, the World Anti-Doping Code prohibits the use of diuretics, etc., and in Japan, a physician prescription is required to purchase diuretics and diet pills. It is highly likely that this hurdle is also a reason for not using medicine to promote weight loss.

Until now, studies on weight loss for judo competitions in Japan have focused on the conditions of junior and senior high school students, university students and adults. However, no research has been conducted on weight loss in the KOSEN category and the situation of this category is still largely uninvestigated. Therefore, we attempted to identify the magnitude and method of weight loss in the KOSEN category of judo competition by conducting a survey of the actual situation. As a result, we found that, although many athletes in the KOSEN category were able to lose weight in an appropriate manner overall, some individuals chose to lose weight rapidly or multiple times during the year, which may pose health risks.

In the future, the following two studies should be conducted. The first is a survey on the actual condition of weight loss, not only at All Japan Technical College competitions but also at Regional Technical College Championships. The results of such a study may provide valuable data for understanding the trend of weight loss in each category of KOSEN. In other words, it is possible that the athletes participating in the Regional Technical College Championships may have used incorrect methods such as rapid or frequent weight loss. Therefore, it is necessary to conduct a survey on the actual condition of weight loss, including those at regional collegiate athletic meets, and to investigate all of them in the future.

The second is the development of a weight-loss programme for judo athletes in the KOSEN category. In this study, it was found that non-professionals such as another judoka, a former judoka, judo coach/*sensei*, and parents provided nearly all of the co-operation and guidance for the athletes' weight loss. This suggests the possibility that those close to the athletes are providing substantial weight loss support, but if the aforementioned parties have incorrect knowledge or ideas, the health of the athletes may be harmed. Therefore, it will be beneficial to develop an educational programme for weight loss based on the specific conditions of the KOSEN category and to train instructors and supporters who can help each athlete lose weight in an appropriate manner.

CONCLUSION

In this study, we attempted to identify the magnitude and methods of weight loss among KOSEN judo athletes in Japan by conducting a questionnaire survey on weight loss among the athletes who participated in a judo competition at the All Japan Technical College Judo Championship. As a result, the following three findings were obtained:

1. Among the athletes in this study, rapid weight loss was observed in 16 out of 36 athletes (44.4%) who lost weight within a week, while 3 of them lost ≥ 5% of their body weight. The minimum age at which weight loss was first performed was 12 years old.

2. Non-professionals such as another judoka, a former judoka, judo coach/*sensei*, and parents provided co-operation and guidance to the athletes for their weight loss. In addition, specialists such as physicians and physical trainers were never involved in the weight loss process.

3. Most of the athletes in this study used gradual weight loss and increased exercise, while extreme weight loss methods such as fasting, diuretics and laxatives were never used.

Many participants in this survey selected appropriate weight loss methods but some selected methods with health risks, such as rapid weight loss and multiple occasions of weight loss in a year. In the future, it would be beneficial to conduct additional surveys, not only on athletes participating in the All Japan College Judo Championship but also in the Regional College Athletic Judo Championship, and to develop educational programmes for weight loss for those involved in judo competitions at technology colleges.

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Finger Injuries in International Judo Competitions

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Abstract: *The purpose of this study was to investigate and examine the actual situation of hand injuries, including finger and fingernail injuries, which are currently of concern to the International Judo Federation (IJF), and to contribute to the revision of regulations, if necessary, for the development of judo. The results showed that the overall incidence of injuries on hands and fingers, including fingernails, was 0.99% of contests in international competitions (i.e. 27 injuries in 2,716 contests from world judo championships in 2021, 22, 23, and 24), which is much higher than judo's common injuries (i.e. knee, shoulder, elbow, head). In 22 cases (82%), injuries occurred when the hand holding the judo suit was separated or pulled apart suddenly and forcibly from tsurite (i.e. collar hand) or hikite (i.e. sleeve hand). In terms of kumite, 17 cases (63%) of the contests were ai-yotsu kumite (i.e. the same kumite as the opponent) and 10 cases (37%) were kenka-yotsu kumite (i.e. opposite kumite to the opponent). The middle finger appeared to be more injured than the other fingers. The incidence of hand/finger injuries varies in the literature, however, the current study postulates that hand/finger injuries are one of the most common injuries in judo at present, which could be reduced under the control of the IJF by changing judo rules and suits in the future.*

Keywords: *injury; finger; hand; fingernails; world judo championship*

Judo has maintained its status as an Olympic Games event from the 1964 Tokyo Olympics (Kodokan Judo, 1964) to the present (i.e. 2024 Paris Olympics). In 60 years, judo has developed globally, growing into a sport supported widely around the world. As of March 2025, 205 federations by country are members of the International Judo Federation (IJF). Judo is a contact sport that could often cause sport-related injuries, compared to non-contact sports (Bromley et al., 2018). We reported previously that judo caused the highest incidence of sport-related injuries (i.e. 106.4% per year, which means one *judoka* gets injured at least once a year) among more than 25 independent sports over 5000 collegiate athletes (Kamiya et al., 2016). It is common to see *judoka* injuring their fingers and other parts of their body in contests and practices (i.e. *randori*), or taping fingers to prevent potential injuries. In addition, there are certain cases of bleeding from fingers and fingernails in competitions and the ongoing contests are interrupted due to first-aid treatment, potentially giving judo a negative image of being a 'dangerous' or 'unhygienic' sport. This situation can be of concern for women's judo in terms of a cosmetic standpoint. Interestingly, 44% of female *judoka* were concerned about finger deformities, which was significantly higher than for male *judoka* (i.e. 14%) (Yamamoto et al., submitted). It might be ideal to develop a new judo suit that makes it difficult to release the gripped hand from offensive and defensive sides, to reduce the burden on the fingers while doing judo, and to prevent injuries on hands and fingers, including cracked nails, swollen finger joints, abrasions, etc. In the literature, no study investigates the correlation between the injury rate and the judo suit change. We have limited data using a sample judo suit from the IJF, in which the collar of the sample judo suit is softer than the current one. Using the sample judo suit, 93% of *judoka* recognised no change in the damage to fingers, postulating that the softer collar change does not help to reduce finger injuries (data not shown).

Studies on ACL injury, *shime-waza* and others were reported recently and accumulated (Matsunaga et al., 2021; Nimura et al., 2022; Kamiya et al., 2023; Sasaki et al., 2023; Yamamoto et al., 2024). The incidence of hand/finger injuries varied from 5% to 30% by reviewing studies before 2009 (Pocecco et al., 2013; Blach et al., 2022). However, injuries on the hands and fingers in judo competitions are not exclusively investigated or updated (Akoto et al. 2018; Frey et al., 2019). The rule of judo defined in the IJF Sport and Organisation Rules is amended year by year to make judo more attractive, with a guarantee of safety management (Calmet et al., 2018; IJf. Sport and Organisation Rules., 2025). The rule change makes significant impacts on the use of judo techniques for judoka, with the consequences of injury characteristics. In 2025, the penalty for fingers inside the sleeve and for a pistol grip were deleted. The purpose of this study was to focus on the incidence of finger/hand injuries in recent international judo competitions before the new rule of 2025, together with investigating factors related to the injuries.

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METHOD

This study was approved by the IRB committee at Tenri University. To obtain actual conditions of hand/finger injuries, including fingernail injuries, in international judo competitions, 3 reviewers reviewed records of contests at the world judo championships (WJC), for the most recent four editions 2021, 2022, 2023, and 2024 (7 men's weight categories and 7 women's weight categories, 14 weight categories in total).

Contests recorded by the IJF were viewed and scenes were investigated carefully, in which the head referee identified the athlete's injury on the finger/fingernail/hand, followed by receiving treatment at the medical table beside the *tatami*. Four items were recorded from each event: manufacturer of the opponent's judo suit, *kumite* (i.e. grips) of the two athletes, the circumstances and mechanism of the injury that occurred in the contest, and the type of injury (bleeding, nail cracking without bleeding, etc.) and location of injury (the finger of thumb, index, middle, fingers, ring, and little, dorsum of the hand, palma of the hand, etc.). The results obtained were analysed statistically by Pearson's Chi-squared test using SPSS (ver. 29). P-values under 0.05 were considered to be significant.

RESULTS

In this study, we analysed 1467 men's contests and 1249 women's contests from the four recent WJCs. The total number of contests for each weight category was as follows: for men, 60kg 185 contests, 66kg 227 contests, 73kg 232 contests, 81kg 247 contests, 90kg 224 contests, 100kg 189 contests, over 100kg 163 contests, and for women, 48kg 188 contests, 52kg 179 contests, 57kg" 184 contests, 63kg 193 contests, 70kg 189 contests, 78kg 154 contests, and over 78kg 162 contests.

Incidence of hand injuries in international judo competitions

Of the total 2716 contests, 27 contests (27 cases, 0.99% of matches) were treated, in total, at the medical table in the four competitions, due to injuries on the hand, finger or fingernails. There were no cases of repeated injuries within the same contest. Of these, 17 contests (17 cases, 1.16% of contests) of the 1467 contests occurred in men, and 10 contests (10 cases, 0.80% of contests) of the 1249 contests occurred in women (Table 1). There was no statistical difference in the overall incidence from the data of four WJCs by gender.

Also, the incidence of the injury on hand, finger or fingernails in each competition from 2021 to 2024 was shown below (Tables 2-5). Five to eight cases were identified in each competition and statistically there was no difference by gender throughout the four WJCs.

In addition, the incidence of injury per 1000 contests was calculated because this presentation is used in some studies (Mooren et al., 2023). From this study, the incidence of injuries on hands, fingers or fingernails, including men and women, was 10 per 1000 contests (Table 6). There were no significant differences in 7 categories in total (i.e. lightest, light, light-middle, middle, middle-heavy, heavy, and heaviest). However, there is a tendency to show higher incidence in the middle categories; 81kg in men ($p=0.054$) and 70kg in women ($p<0.01$, but limited sample size).

Investigation of injuries by judo suit, *kumite*, injury type and mechanism

A total of 27 injuries occurred in four competitions. The manufacturers of the judo suits worn by the opponents at the time of injury were investigated. The results showed that Kusakura (Japan) accounted for seven contests (26%), Mizuno (Japan) for six (22%), Adidas (France) for five (18%), Ippongear (Germany) and Green Hill (Germany) each for two (7%) and Essimo (Netherlands), Daedo (Spain), Fighting Films (Great Britain), Hiku (Switzerland) and Fightart (France) for one (4%), with Japanese manufacturers accounting for 48% of the total (Figure 1). Note that the proportion of manufacturers of the judo suit worn by all athletes participating in the four WJCs was not investigated at this time.

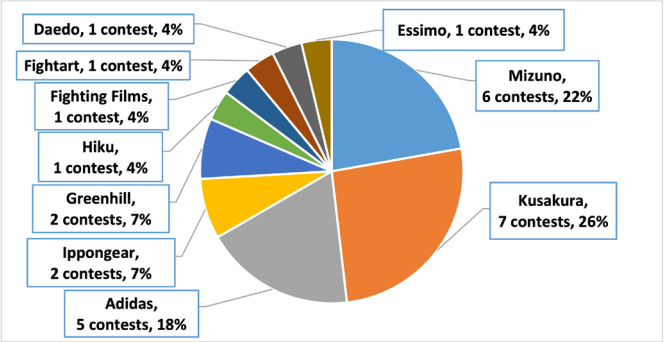

Figure 1. Manufacturers of judo suits worn by opponents at the time of injury

Next, we investigated the *kumite* at the time of injury and compared *ai-yotsu kumite* (i.e. the same *kumite* between the two *judoka* in the contest) and *kenka-yotsu kumite* (i.e. the opposite *kumite* between the two *judoka* in the contest). In terms of *kumite*, 17 cases (63%) of the matches were *ai-yotsu kumite* and 10 cases (37%) were *kenka-yotsu kumite* (Figure 2). There was no statistical difference by *kumite* pattern in the incidence of hand/finger injuries from the four WJCs.

Table 1. Total number of injuries on hand, finger or fingernails for all four WJCs

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total	Total number
Contest	185	227	232	247	224	189	163	1467	
Injury	3	2	2	5	2	2	1	17	
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total	Contests 2716
Contest	188	179	184	193	189	154	162	1249	Injury 27
Injury	2	0	2	0	4	1	1	10	

Table 2. Total number of injuries on hand, finger or fingernails for 2021 WJC

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total	Total number
Contest	49	62	65	80	60	54	35	405	
Injury	2	0	1	2	0	0	0	5	
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total	Contests 709
Contest	48	48	42	48	41	34	43	304	Injury 6
Injury	0	0	0	0	1	0	0	1	

Table 3. Total number of injuries on hand, finger or fingernails for 2022 WJC

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total	Total number
Contest	45	47	54	50	52	44	39	331	
Injury	0	1	1	2	0	0	1	5	
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total	Contests 612
Contest	41	37	45	44	46	36	32	281	Injury 8
Injury	0	0	0	0	1	0	0	1	

Table 4. Total number of injuries on hand, finger or fingernails for 2023 WJC

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total	Total number
Contest	40	58	58	54	61	47	46	364	
Injury	0	0	0	0	1	0	0	1	
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total	Contests 698
Contest	48	48	53	49	52	40	44	334	Injury 5
Injury	1	0	1	0	2	0	0	4	

Table 5. Total number of injuries on hand, finger or fingernails for 2024 WJC

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total	Total number
Contest	51	60	55	63	51	44	43	367	
Injury	1	1	0	1	1	2	0	6	
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total	Contests 697
Contest	51	46	44	52	50	44	43	330	Injury 8
Injury	1	0	0	0	1	0	0	2	

Table 6. Total number of injuries on hand, finger or fingernails for all four WJCs

Category (Men)	60kg	66kg	73kg	81kg	90kg	100kg	100kg+	Total men
Injury per 1000 contests	16	9	9	20	9	11	5	12
Category (Women)	48kg	52kg	57kg	63kg	70kg	78kg	78kg+	Total wome
Injury per 1000 contests	11	0	11	0	21	6	6	8
Category	Lightest	Light	Light Middle	Middle	Middle heavy	Heavy	Heaviest	

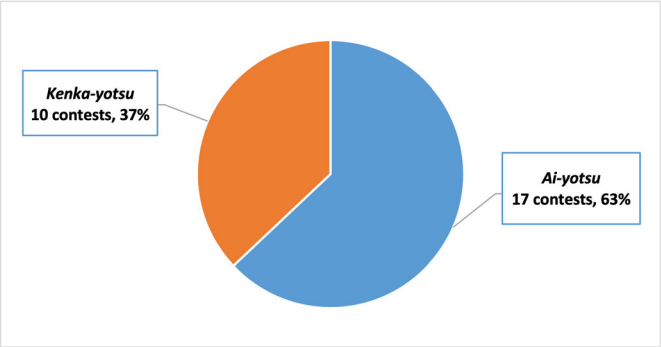

Figure 2. *Kumite* (*ai-yotsu*; the same side, *kenka-yotsu*; opposite side) at the time of injury

In terms of injury scenarios from the 2716 contests covered, 18 (67%) were cases where the fighters were injured when their hands separated during performing techniques or receiving techniques, 5 (18%) were cases where the fighters were injured during a transition from *tachi-waza* to *ne-waza* or during a *ne-waza* fight, and 4 (15%) were cases when the fighters were injured during *kumite* fights (i.e. grip fights) because their hands were rapidly, forcibly released from collar or sleeves of judo suits (Figure 3). Note that in 22 (82%) of the total 27 cases, hands were "separated" or "pulled away" forcefully from the opponent's judo suits (i.e. collars, sleeves) in *kumite* fights or in attacking/receiving techniques.

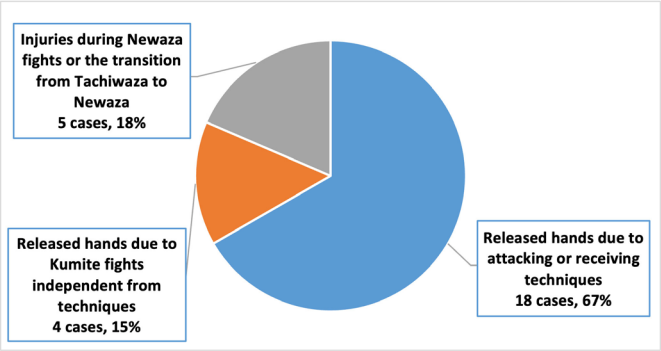

Figure 3. Scenes of injury in matches

Out of 27 cases, 17 (63%) were cases where bleeding from fingers, fingernails or hands was treated, to stop the bleeding, mainly by taping at the medical table. The rest, 10 (37%) were cases where nails were cracked without obvious bleeding (data not shown). In terms of the location of injuries, 12 (45%) were cases where injuries occurred in the middle finger, and 7 (26%) were cases in the thumb (Figure 4). While 18 cases (67%) were injured in the left hand and 9 cases (33%) were in the right hand, there was no correlation between injury side (i.e. right, left) and *kumite* pattern (i.e. *ai-yotsu kumite, kenka-yotsu kumite*, data not shown).

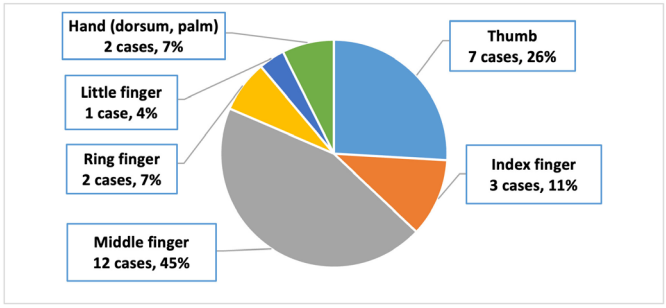

Figure 4. Injury locations

DISCUSSION

Hand/finger injuries in international competitions

A survey of recorded contest videos from the most recent four world judo championships, organised by the IJF, revealed that in 27 out of 2716 contests (0.99% of contests), competitors received treatment by first aid personnel due to injuries involving their hands and fingers, including fingernails. When the time to injury for all 27 cases was investigated, 9 occurred within 2 minutes, 14 occurred within 4 minutes and 4 were in the golden score period. The mean time was 143.6 seconds, indicating a tendency for finger injuries to occur in the latter part of the contest, while the difference was insignificant (p=0.083).

22 (82%) of 27 cases may occur when the collar hand (i.e. *tsurite*) or sleeve hand (i.e. *hikite*) was released or pulled away suddenly and forcefully from the opponent's judo suit, presumably due to strong external forces (i.e. traction) during the repeat of attack and defence in contests. There are two kinds of *kumite*; one is right-hand up (i.e. right *kumite*), another is left-hand up (i.e. left *kumite*). The way of *kumite* is fixed by each *judoka* and is rarely changed during the contest. When injuries occurred during contests between two competitors, ai-yotsu *kumite* (i.e. both competitors use the same right or left *kumite*) was identified in 17 cases (63%) and kenka-yotsu *kumite* (i.e. one uses right *kumite* and another uses left *kumite*) was identified in 10 cases (37%) (Figure 2). While the current data was insignificant (p=0.178), it can be speculated that ai-yotsu *kumite* can offer a risk of finger injuries.

Pre-emptively taped fingers and finger injuries are both obvious in judo competitions, which may lead to a negative image of judo via TV broadcasts. Thus, concerning hand and finger injuries, including fingernail injuries during contests, can be considered problematic by the IJF. The results of the present study show that the incidence of injury per contest was 0.99%. Smolders et al. analysed a total of 664 cases of injury (361 men; 303 women) in 123 European judo competitions from 2005 to 2019 (e.g., European Open and European Championships), in which a total of 25,397

competitors (14,664 men, 10,733 women), were analysed for injuries. In those, the locations of 632 injuries were identified and hand injuries accounted for 43 cases, which were 6.8% of the total number of injuries and 0.17% per competitor (Smolders 2021). In the current study, the number of competitors from 4 world championships was 2547 (1385 men, 1162 women), in which 27 cases of injuries occurred (i.e. 1.06% per competitor), indicating a higher incidence than Smolders et al. study. When the number of contests studied by Smolders et al. is roughly calculated as 12,699, hand injuries were estimated to be 0.34% of contests. The hand injuries, including fingers and fingernails, in this study were 0.99% of contests, which is about three times higher than the number of hand injuries in the Smolders et al. study, but less than 1% in each case. Given that the most common injury in the Smolders et al. study was knee injuries (117 cases), which can be converted to 0.92% of contests based on the same estimated number of contests, it is considered that hand injuries, including fingers and fingernails, were relatively common. A similar incidence of the hand injury per contest was reported as 0.33% (Blach, et al., 2021). It has been reported that the location of judo's common injuries was the knee, shoulder, elbow, lower back or head (Pocecco et al., 2013; Bromley et al., 2018; Mooren et al., 2023), however, it is possible that hand/finger injuries are the most frequent in judo.

Limitations of this study

Statistical analyses were performed regarding the incidence of hand/finger injuries per contest with gender, three weight categories (Green et al., 2007), and result (win or loss). However, no significant differences were identified at this time, in part due to limited sample size (data not shown). Thereby, characteristics of injuries including hands, fingers or fingernails, comparing by gender, weight category and result, are of interest in an extension study with an increase in sample size. Hand injuries, including finger and fingernail injuries, occur not only in international competitions but also in daily practice in judo clubs. Injuries during contests are much more frequent than those during practices, as reported in other sports (Hootman et al., 2007). Future study is desired to investigate the incidence of injuries on hands, fingers and fingernails in judo practice when compared with competitions.

CONCLUSION

We surveyed contests from the most recent four world judo championships, 2021-2024, and revealed that 27 out of 2716 contests (0.99% of matches) included treatment at the medical table due to injuries on hands, fingers or fingernails. The incidence of 0.99% of contests was likely relatively higher than other injuries, suggesting that hand injuries, including finger and fingernail injuries, appear to be common in judo and are currently of concern to the IJF. No significant differences were identified statistically regarding gender, weight category or contest result. This study is important because it focuses on the details of hand/finger injuries in judo uniquely and could contribute to the revision of the rules for the development of judo, if necessary, in the future.

ACKNOWLEDGEMENTS

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Characteristics and Awareness of Finger Injuries in Japanese Collegiate Judokas

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Abstract: *The purpose of this study was to clarify the attitude and awareness towards finger injuries in judoka, which has not been fully investigated in the literature. We conducted an awareness survey on finger injuries for 218 college judoka (148 men and 70 women). Almost all judoka (98%) had experienced finger injuries in the past and kumite fights were the most frequent occasions to cause finger injuries (64%), which included abrasions (bleeding), dislocation, fracture, ligament injury, and fingernail injuries (split, peel). In addition, 59% of judoka recognised their finger deformities, 28% of them had pain daily and 13% faced difficulties in daily life due to injuries. Deformities were most frequently found on ring fingers. Compared with males, females were more concerned about finger deformities at the time of the study (men 14%, women 44%) and about them remaining in the future (men 14%, women 56%). Most judoka (men 94%, women 91%) recognised finger deformities as an unavoidable part of judo. The experience and awareness of finger injuries were similar to that of deformed ears. Furthermore, judoka tend to not take finger injuries seriously because only 1/5 (19%) judoka reported their fingers to their coaches and 1/4 judoka (26%) saw a doctor. Judoka were less aware that a cause of finger injuries could be the material and shape of judo clothing. This study is significant in providing a milestone regarding the attitudes and awareness towards finger injuries in judoka.*

Keywords: *finger injury, finger deformity, university, gender difference, acceptance*

In the literature, the locations of judo's common injuries have been reported in the knee, shoulder, elbow, lower back, and head (Green et al., 2007; Pocecco et al., 2013; Bromley et al., 2018; Blach, et al., 2021; Blach, et al., 2022; Mooren et al., 2023). Judo is one of the contact sports that could often cause sport-related injuries (Bromley et al., 2018). Judo caused the highest incidence of sport-related injuries in college judoka (Kamiya et al., 2016). While severe injuries have had more attention, including ACL injury, *shime-waza* and head injuries (Akoto et al., 2018; Frey et al., 2019; Matsunaga et al., 2021; Nimura et al., 2022; Kamiya et al., 2023; Sasaki et al., 2023; Yamamoto et al., 2024), the incidence of hand/finger injuries ranges from 5% up to 30% in some literature (Smolders, 2021; Pocecco et al., 2013). Within hand/finger injuries, the details of finger injuries have not been fully elucidated. It is common to see judoka injuring their fingers in competition or taping their fingers to prevent potential injuries. In addition, there are certain cases of bleeding from fingers and fingernails in competition. Thus, it is hypothesised that finger injury is one of the most frequent injuries in judo competitions and daily practices. The purpose of this study was to obtain fundamental data on judoka's attitudes and awareness regarding finger injuries. The rules around judo techniques are changing to improve, year by year, under the control of the IJF (Calmet et al., 2018; IJF Sport and Organisation Rules., 2025), which may affect the characteristics of injuries. This study is expected to contribute to the evidence of judo when changing judo rules in the future, if necessary.

Studies on ACL injury, *shime-waza* and others were reported recently and accumulated (Matsunaga et al., 2021; Nimura et al., 2022; Kamiya et al., 2023; Sasaki et al., 2023; Yamamoto et al., 2024). The incidence of hand/finger injuries varied from 5% to 30% by reviewing studies before 2009 (Pocecco et al., 2013; Blach et al., 2022). However, injuries on the hands and fingers in judo competitions are not exclusively investigated or updated (Akoto et al. 2018; Frey et al., 2019). The rule of judo defined in the IJF Sport and Organisation Rules is amended year by year to make judo more attractive, with a guarantee of safety management (Calmet et al., 2018; IJf. Sport and Organisation Rules., 2025). The rule change makes significant impacts on the use of judo techniques for judoka, with the consequences of injury characteristics. In 2025, the penalty for fingers inside the sleeve and for a pistol grip were deleted. The purpose of this study was to focus on the incidence of finger/hand injuries in recent international judo competitions before the new rule of 2025, together with investigating factors related to the injuries.

METHOD

A survey of finger injuries of collegiate judoka (age: 18-22 years) in Japan was conducted in 2024. This study was approved by the IRB committee at Tenri University. We generated a questionnaire on finger and fingernail injuries with 18 items to investigate the reality and perception of finger injuries from the perspective of competitive judoka. We recruited 218 collegiate judoka (148 men and 70 women)

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and the results obtained were analysed statistically by Pearson's Chi-squared test using SPSS (ver. 29). P-values under 0.05 were considered to be significant. The obtained p-values were also confirmed by the Fisher exact test.

RESULTS

Actual conditions of finger injuries of collegiate judoka in Japan

When asked whether they had ever had a finger injury in judo, 213 athletes (98%) responded "yes," indicating that almost all athletes have experienced finger injuries in their judo careers (Figure 1).

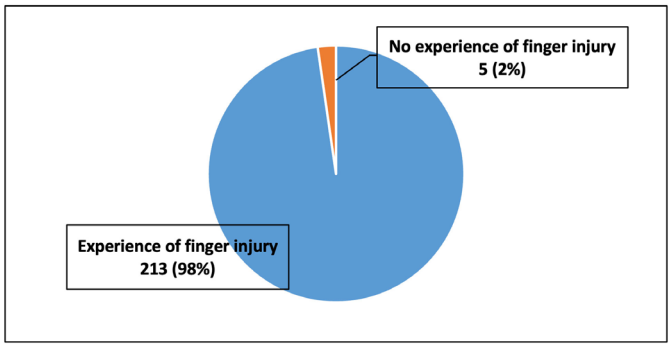

Figure 1. The experience of finger injury in Judoka careers

Regarding the circumstances of the finger injury with multiple responses to the question, 199 (64%) had the injury in *kumite* fights (e.g. grip fights, pulled away from a paired hand), 53 (17%) in technique attacks, 29 (9%) in being thrown, and 25 (8%) in *ne-waza* fights. Note that 81% of finger injuries occurred from the *kumite* for techniques in *tachi-waza* (Figure 2).

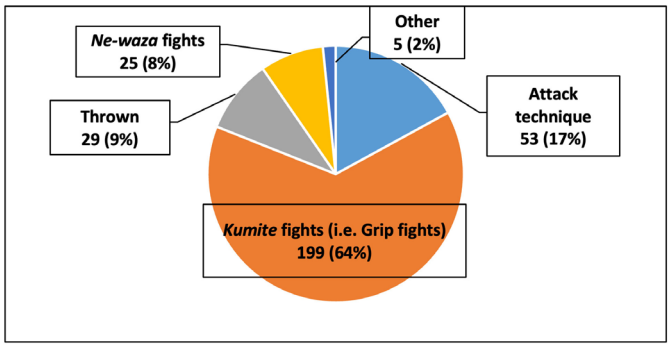

Figure 2. The situation of finger injury experienced in the past

Regarding the description of finger injuries with multiple responses to the question, 172 (30%) cases were jammed finger or ligament injury (except dislocation), 153 (27%) cases were nail-related injuries (split nail or peeled nail, etc.), 111 (20%) cases were abrasions (bleeding, etc.), 69 (12%) cases were finger fractures, 58 (10%) cases were finger dislocations (Figure 3). Note that some finger injuries were considered serious and nail injuries and abrasions were common.

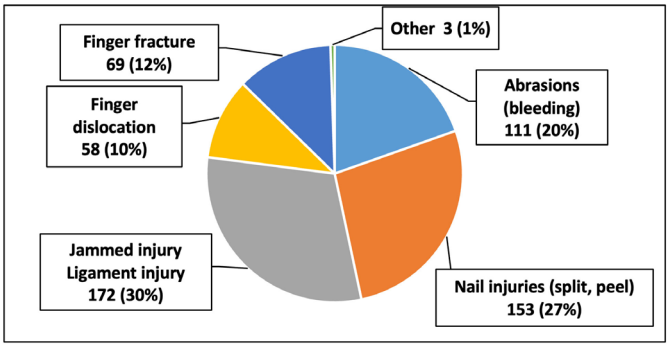

Figure 3. Description of finger injuries in competitive judoka

In 218 judoka, 129 (59%) recognised having deformities in their fingers, while 89 (41%) recognised no deformity (Figure 4).

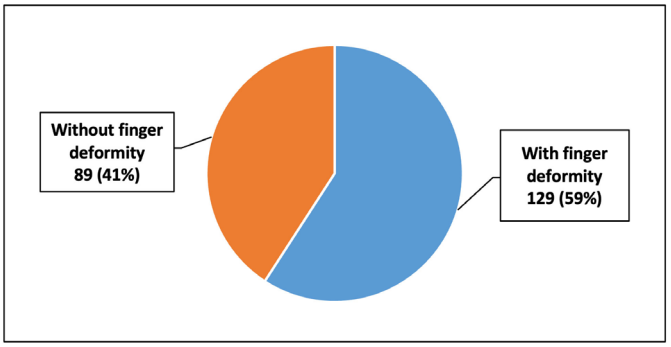

Figure 4. Self-assessment of finger deformity in judoka

Regarding the self-assessment of the location of finger deformity, 24 (10%) cases were confirmed in the thumb, 24 (10%) were in the index finger, 58 (24%) cases were in the middle finger, 88 (37%) cases were in the ring finger, and 47 (19%) cases were in the little finger (Figure 5). Note that the number for the ring finger was significantly higher than the other four fingers and the number of the little finger and the thumb was significantly lower ($p<0.001$).

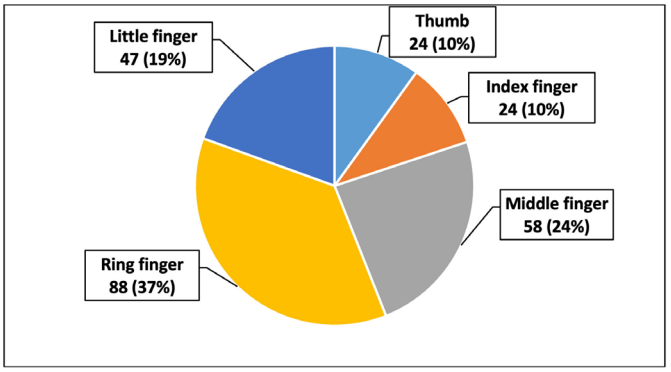

Figure 5. The location of finger injuries in judoka experience

When asked if they had pain in their fingers daily at the time of the questionnaire, 61 (28%) replied that they had pain and the rest 157 (72%) responded no pain (Figure 6).

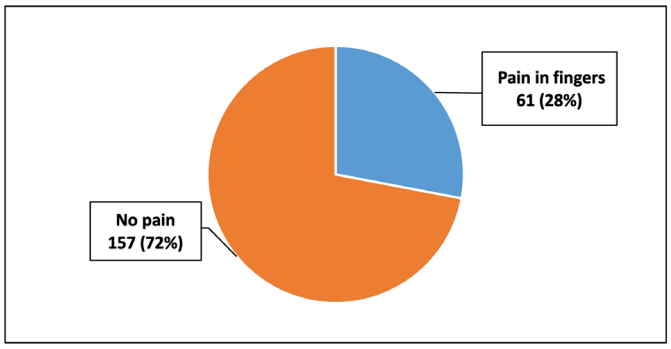

Figure 6. Daily finger pain at the time of the questionnaire

When asked whether they have any difficulties in their daily life as a result of their finger injury, 28 (13%) recognised difficulties in something and 190 (87%) did not (Figure 7).

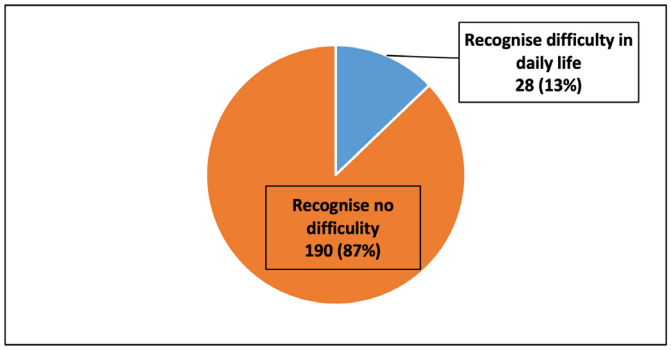

Figure 7. Difficulties in daily life due to finger injuries

When asked whether they report finger injuries to their coaches, 175 (80%) would not report, 41 (19%) would report (Figure 8).

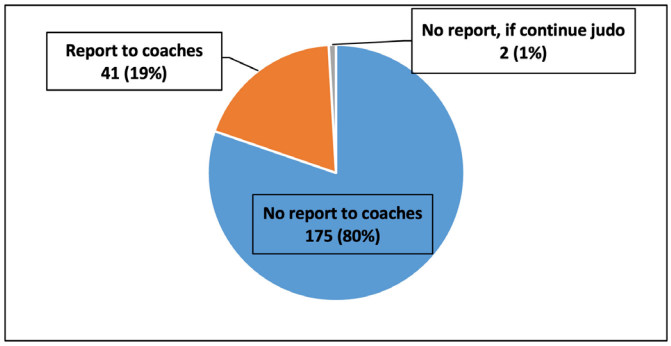

Figure 8. Report to coaches about finger injury

When asked whether they would go to see a doctor (including orthopaedics and osteopaths) when they have a finger injury, 162 (74%) would not go and 56 (26%) would go (Figure 9).

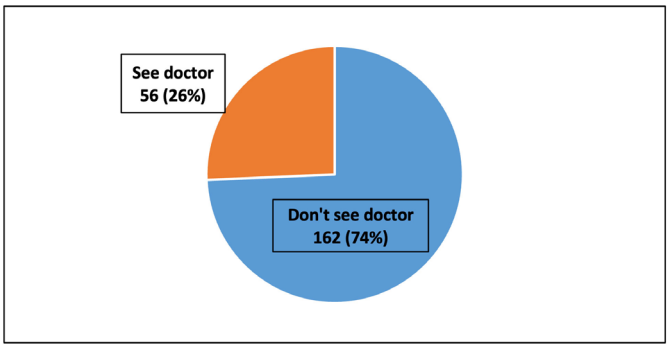

Figure 9. Report to coaches about finger injury

Regarding the most frequent period when finger injuries occurred, 133 (61%) judoka were in high school, 54 (25%) judoka were in university, 22 (10%) judoka were in junior high school and 8 (4%) judoka were in primary school (Figure 10).

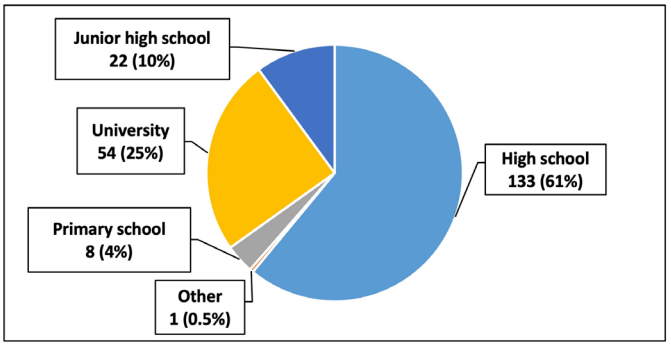

Figure 10. The most frequent life stage for finger injuries

When asked whether they always wear taping to protect their fingers during judo practice, 123 (56%) judoka always wore taping, 92 (42%) judoka did not wear it and 3 (2%) judoka sometimes or occasionally wore taping (Figure 11).

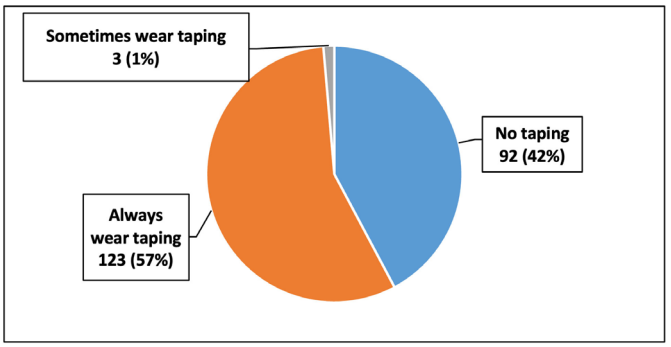

Figure 11. Wear tape during judo practice

When asked if they were concerned about finger deformities at the time of the questionnaire, 166 (76%) judoka were not concerned, but 52 (24%) judoka were concerned (Figure 12).

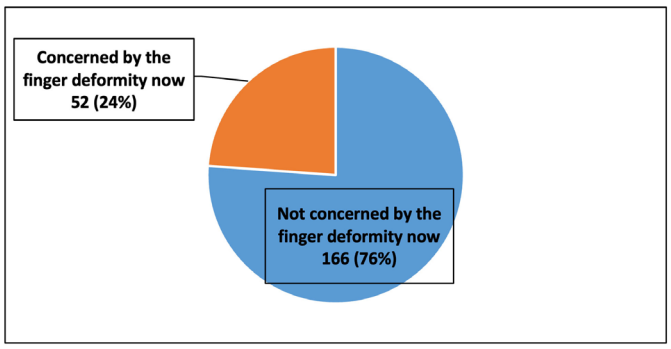

Figure 12. Concern for finger deformity at present

When gender difference was highlighted, 21 out of 148 (14%) men and 31 out of 70 (44%) women were concerned about the finger deformity, in which women were significantly higher than men by the Fisher exact test ($p < 0.001$, Figure 13).

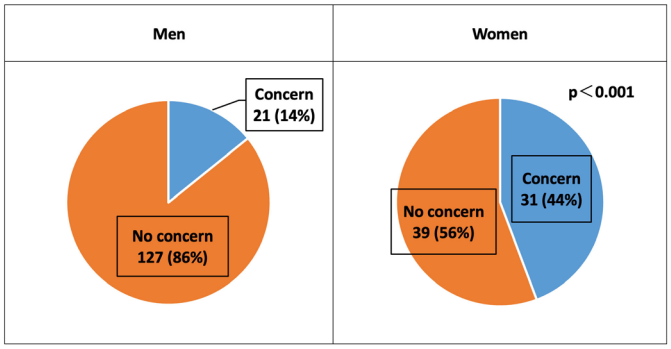

Figure 13. Concern for finger deformity at present, demonstrated by gender

When asked whether they are concerned about finger deformities remaining in the future, 158 (72%) judoka were not concerned, while 60 (28%) judoka were concerned (Figure 14).

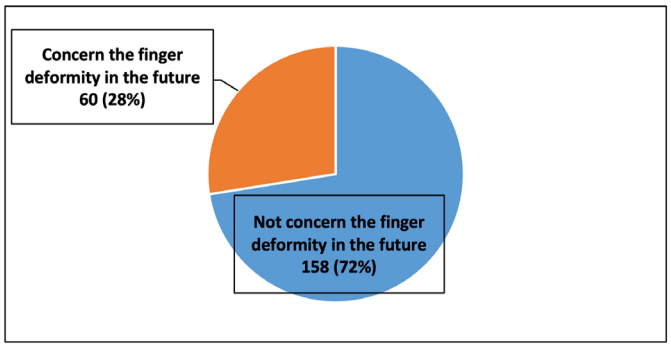

Figure 14. Concern for finger deformity remaining in the future

When gender differences were highlighted, 21 out of 148 (14%) men and 39 out of 70 (56%) women were concerned about finger deformities remaining in the future, in which women were significantly higher than men, using the Fisher exact test ($p<0.001$, Figure 15).

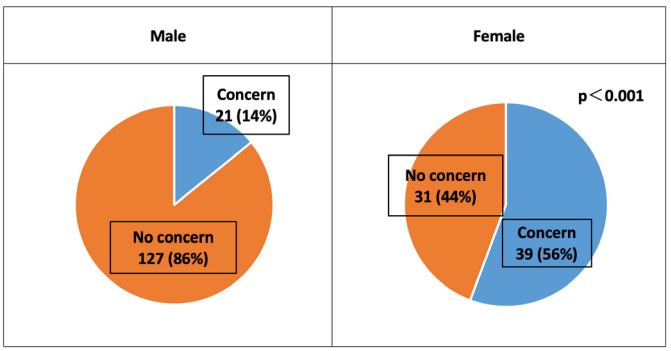

Figure 15. Concern for finger deformity remaining in the future, presented by gender

When asked whether finger deformity was an unavoidable part of judo, 203 (93%) judoka thought that it was an unavoidable part of judo but 15 (7%) judoka did not (Figure 16).

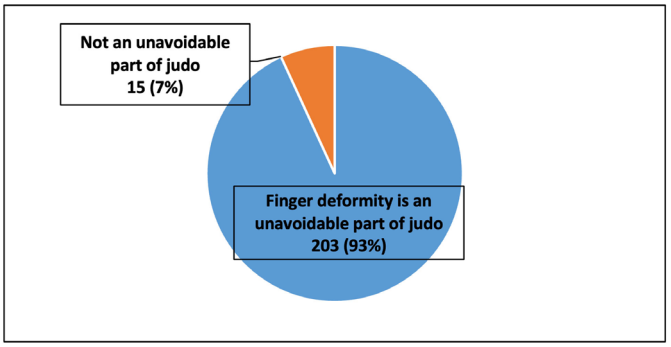

Figure 16. Awareness of finger deformity as 'unavoidable'

Regarding the awareness of finger deformity as an unavoidable part of judo, 139 out of 148 (94%) men and 64 out of 70 (91%) women recognised it as unavoidable (Figure 17).

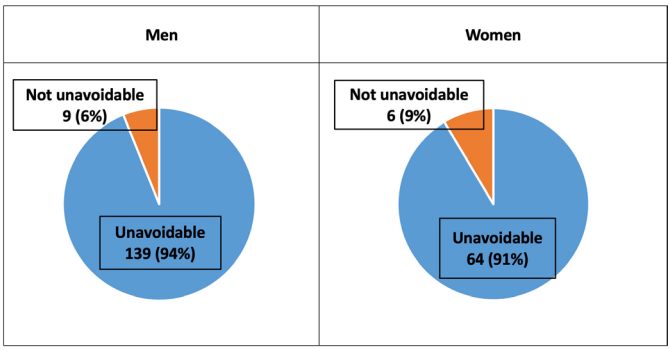

Figure 17. Awareness of finger deformity, presented by gender

Regarding the self-assessment of ear deformity, 104 (48%) judoka had both ears deformed, 58 judoka had one of their ears deformed (26%; right ear 7%, left ear 19%), and 56 (26%) judoka had no deformity (Figure 18). Note that 162 (74%) judoka had at least one deformed ear.

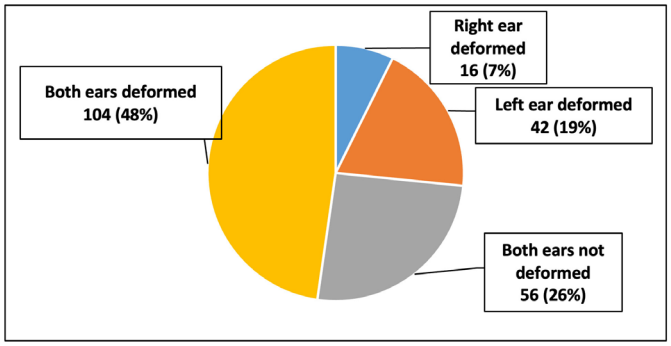

Figure 18. Self-assessment of ear deformity in judoka

Ear deformities were significantly higher in men than in women (p=0.012, Figure 19).

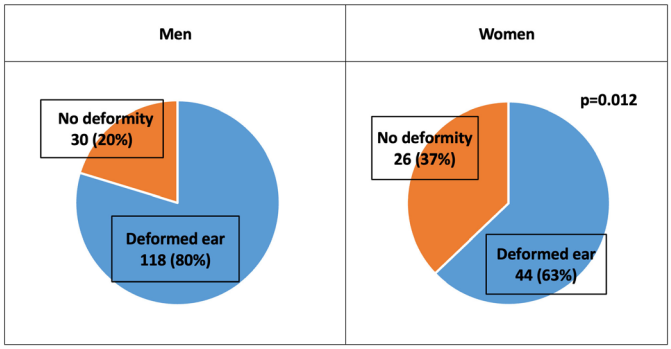

Figure 19. Ear deformity presented by gender

When asked if they were concerned about their ears being deformed, 150 (69%) judoka were not concerned, but 65 (30%) judoka were aware of their ears being deformed (Figure 20).

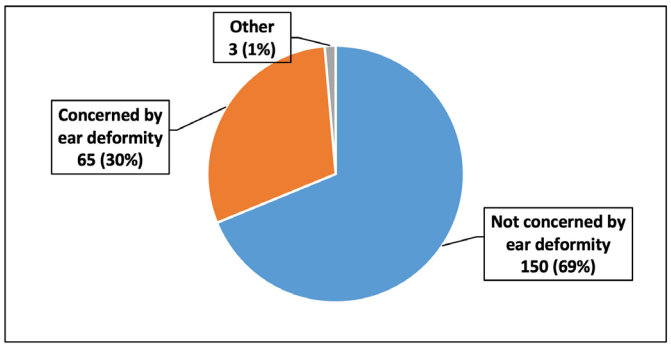

Figure 20. Concern for ear deformity in judoka

When gender differences were highlighted, 30 out of 148 (20%) men and 35 out of 70 (50%) women were concerned about their ears being deformed, in which women were significantly higher than men, using the Fisher exact test (p<0.001, Figure 21).

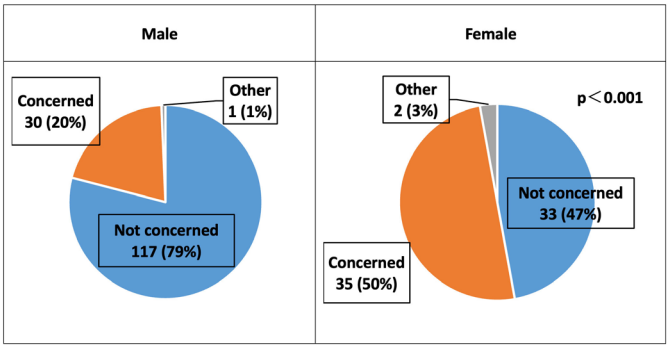

Figure 21. Concern for ear deformity, differentiated by gender

When asked whether ear deformity was an unavoidable part of judo, 200 (92%) judoka thought it unavoidable but 18 (8%) judoka did not (Figure 22).

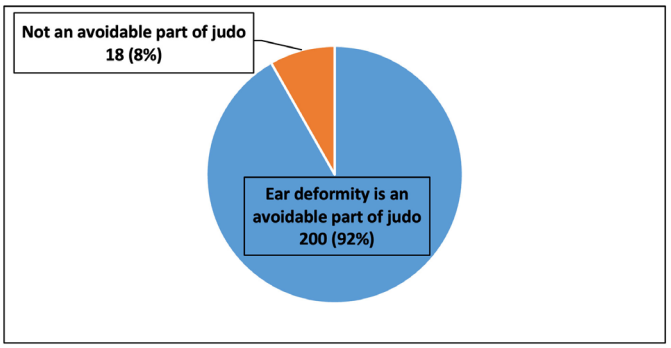

Figure 22. Awareness of ear deformity as unavoidable

Moreover, 138 out of 148 (93%) men and 62 out of 70 (89%) women recognised it as unavoidable (Figure 23).

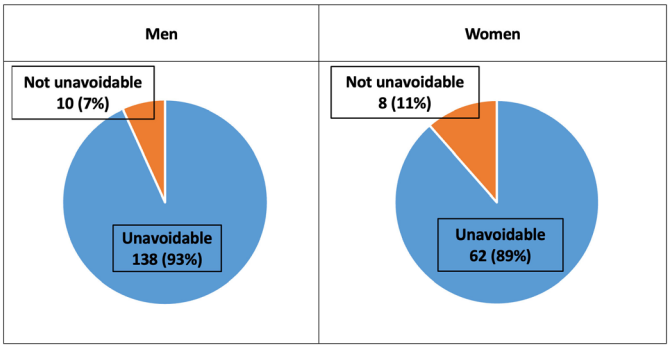

Figure 23. Awareness of ear deformity presented by gender

When asked to provide multiple responses to the question of how to reduce finger injuries, 143 (49%) judoka proposed finger and nail protection (e.g. wearing gloves, nail protection), 99 (34%) judoka proposed improving muscle strength (e.g. grip strength), 28 (10%) judoka proposed improving judo suits (e.g. changing the clothing material), and 16 (6%) judoka proposed changing the rules (e.g. prohibiting more than necessary *kumite* fights (Figure 24).

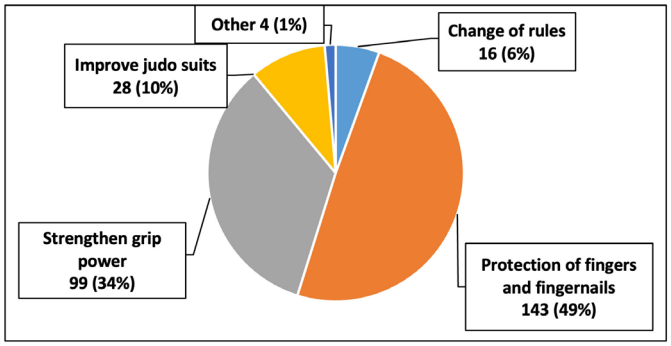

Figure 24. Potential revision and improvement to reduce finger injuries

Regarding the care of nails with multiple responses to the question, 214 (94%) judoka clipped their nails, 11 (5%) judoka overlaid their nails (e.g. topcoat, athlete nails), and 3 (1%) judoka did nothing at all for their nails (Figure 25).

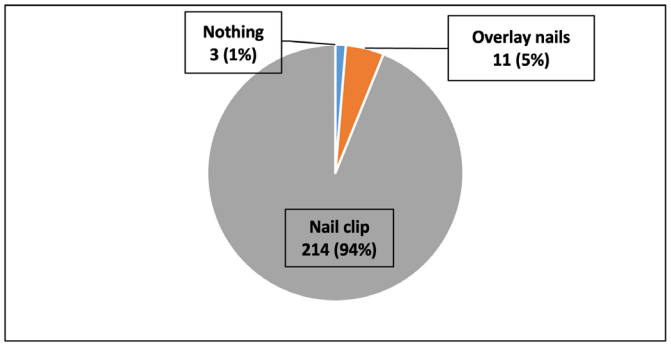

Figure 25. Nail care in judoka

DISCUSSION

Actual conditions of finger injuries among collegiate judoka in Japan

The present survey of finger injuries, including fingernail injuries, among university judoka was conducted based on the hypothesis that finger injuries occur to a certain extent in judoka. The results showed that almost all judoka (98%) had experienced finger injuries, which was more than expected. On the other hand, almost all judoka (99%) were taking care of their nails, including nail clipping and nail protection (e.g. overlay nails), as is stated in the IJF Sport Organisation Rules (SOR), “The nails of the feet and hands must be cut short” (IJF Sport and Organisation Rules, 2025). However, regarding the type of injury in the survey, about a quarter (27%) of the judoka had experienced nail injuries before, such as split nails or peeled nails. Although nail care seems to be a prerequisite in judo (i.e. 99%), it can be inferred that in reality the fingers are subjected to external forces during competition that cannot be dealt with by these measures, leading to such nail injuries. In other words, there is a demand to overcome nail injuries using a new method, considering that judo is a combat sport in which extremely strong external forces are exerted on the body, including fingernails.

In addition, regarding the period of high incidence of finger injuries, 133 (61%) judoka were in high school and 54 (25%) judoka were in university. This may be partly because the level of competition generally increases in high school and university due to physical growth and judo experience, enabling high-intensity, complex movements and strong-force attacks and defences. While 213 (98%) judoka had experienced finger injuries, 61 (28%) judoka had daily pain at the time of this survey. Due to the nature of judo as a contact sport and a martial art, finger injuries may occur daily. Thus, it is also possible that the high incidence of finger injuries makes judoka have a higher tolerance for the pain caused by finger injuries.

Furthermore, one fifth of judoka (41, 19%) reported to their coaches about their fingers. In addition, a quarter of judoka (56, 26%) saw a doctor (including orthopaedics, osteopaths, etc.). These results indicate that in addition to pain tolerance, judoka tend to not take finger injuries seriously. Regarding finger deformity in judoka, 21 (14%) men and 31 (44%) women were aware of their finger deformities, and 21 (14%) men and 39 (56%) women were concerned about the deformity remaining in the future. In this survey, female judoka were significantly more concerned about finger deformity than male ($p<0.001$). This may be of particular concern to the IJF; on the other hand, most judoka (93%), including women (91%), considered the finger injury to be unavoidable, highlighting the reality that the injury itself is accepted.

In this study, we investigated the awareness of ear deformity as a control for finger deformity. It was found that 30 (20%) male and 35 (51%) female judoka were concerned, with the percentage of women being significantly higher ($p<0.001$). In addition, most judoka (92%), including women (89%), accepted ear deformities as an unavoidable part of judo. Note that this phenomenon is similar to the finger deformity. Ambo et al. (2011) reported that approximately 70% of adolescent females were dissatisfied with physical characteristics other than weight and shape and that approximately 40% of adolescent females with body dissatisfaction were dissatisfied with their face, skin and hair. Foley Davelaar (2021) described that in adolescence, body image becomes a significant determinant of the continuation of physical activity, more than actual skill. Thus, it can be inferred that competitive judoka, especially female athletes, are also more likely to have negative feelings towards finger deformities and ear deformities. Nevertheless, the fact that many judoka accept finger and ear injuries and the resulting aftereffects as unavoidable, continuing to compete, indicates that they understand the characteristics of judo as a martial art and accept the physical risks involved, as well as the injuries to their fingers and nails.

In addition, photographs of the fingers were collected in this study (Figure 26). Finger deformities were detectable in some parts of the fingers by appearance (i.e. red arrows). The findings of this study are of interest because the situa-

tion is accepted objectively, despite deformities in some fingers. Therefore, further research will be needed to continue to examine the relationship between the degree of finger deformity and its perception.

Figure 26. Appearance of bilateral fingers with deformities in some parts

Limitations of this study

This study conducted a current situation and awareness survey on finger injuries to identify trends but a larger sample size would be necessary in the future. Furthermore, while this study focused on university student judoka in Japan, future work is needed to expand the survey to other countries and even age groups and to identify trends among all judoka.

CONCLUSION

To grasp the situation in Japan regarding finger injuries, of which the IJF is concerned, we conducted a questionnaire among college judoka to investigate the experience and awareness of finger injuries from the perspective of active competitors. We found that almost all judoka experienced finger injuries, while they recognised and accepted the injuries as unavoidable. The experience and awareness of finger injuries were similar to those of deformed ears. Judoka were less aware that the cause of finger injuries could be the material and shape of judo clothing. Future studies were desired to analyse the differences between other countries and ages.

ACKNOWLEDGEMENTS

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Ju Do (柔道) as a Complementary Therapeutic Tool for Parkinson's Disease: a Quantitative Single-Study Case

By Attilio Sacripanti[1], Envic Galea[1], Romeo Fabi[2]

Abstract: *This paper describes a quantitative, single-case study applied to Parkinson's Disease, which was born from a research project of the IJF Academy Foundation. The case study was centred around a 66-year-old retired man, height 1.65 m, weight 87 kg. He is a fifth dan judo black belt with akinetic Parkinson's and Pisa Syndrome, high lateral torsion (~14°) and balance problems.*

This article describes the protocol used and quantitative results obtained. The experimental data collected indicates that a judo sequence called gensoku no genkei (原則の原型) can be useful, in its safe form, as a therapeutic tool at any stage of Parkinson's Disease. The lack of a potential painful state after the sequence, the quantitative improvement in standard senior tests, and in some specific tests based on ukemi (breakfall techniques), improvement of the Pisa Syndrome angle and the persistence of results obtained, demonstrate the effectiveness of this application of judo for Parkinson's.

The method led to an improvement in daily quality of life, clearly demonstrating the validity of judo and specifically of gensoku as a reparative therapy for functional improvement, even in the advanced stages of Parkinson's Disease.

Keywords: *Parkinson's disease; physical therapy; Gensoku no Genkei; therapeutic tool, quantitative study*

The IJF Academy Foundation is the educational arm of the International Judo Federation and its primary goal is to provide professional education for coaches and standardise their technical knowledge, spreading the judo values, knowledge and an understanding of different applications of judo worldwide. During the last four years, the IJF Academy has tried to diversify the application of judo, given its great adaptability and technical richness, in various fields beyond competitiveness, developing research projects such as safe falling for the elderly (EDJCO Project 2021-2023) and intergenerational integration (JOY Project 2024-2026). Among these projects, special attention was paid to the rehabilitative use of judo in general, with the Parkinson's project is a practical example. This project focused on the analysis of judo's potential effectiveness in a quantitative case study, of which this article is the report. The conclusions are that judo as a specific sequence called *gensoku no genkei* can rehabilitate a patient with Parkinson's disease.

PARKINSONS'S, CURRENT AND NEW HORIZONS: *GENSOKU* AS A THERAPEUTIC TOOL

The rehabilitative goal for patients with Parkinson's Disease is to maximise functional independence and, if possible, enhance their quality of life at all stages of the disease. Balance exercises are normally introduced from an early stage of the disease, to become part of the daily habit of yoga exercise (Van Hulsteyn et al., 2013). Higher-level balance training, such as that provided by tai chi, is also common (Hallet and Poewe, 2008).

Judo can be used for balance issues and the prevention of falls in Parkinson patients (Seminara et al., 2022). Dance therapy has been observed to be beneficial and may have long-lasting effects. In particular, tango training improved mobility and other motor domains (Zafar et al., 2016; Seidler et al.,2016; Wang et al.,2022).

Judo falling techniques (*ukemi*) can be extended, with appropriate precautions, to help the elderly with Parkinsons, as in this case study.

Animal and human studies have revealed that exercise enhances cognition via neurotrophin and catecholamine production, which are known to mediate neural plasticity and energy metabolism in the brain (Gomez-Pinilla et Hillman 2018). It has also been shown that physical training benefits functional connectivity in the medial and lateral temporal cortices (Voss et al., 2013).

One study demonstrated that rodents that participated in complex motor skill learning tasks exhibited a greater num-

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ber of synapses per neuron, a substantially greater volume of molecular layers per Purkinje neuron, and a sufficiently large number of other geometric fractals, such as capillaries (Sacripanti, 2000). Furthermore, in the cerebellum, they showed a significantly greater number of parallel fibres in Purkinje cells, a well-known example of physiological self-organisation (Sacripanti, 2000), compared to animals that simply walked or were inactive (Isaacs et al., 1992).

Exploiting the qualities inherent in judo, a new kata has been developed (an. evolution of the *Itsutsu-No-Kata*), based on the two philosophical principles of judo: *Jita kyoei* (自他共榮) and *Seirioku Zenyo* (精力善用). *Gensoku-No-Genkei* (原理の原型), the archetype of the principle, (Sacripanti, 2022) developed in three forms ('hard,' 'gentle' and 'safe,' is the simplest set of movements, biomechanically speaking, grouped into an open *kata* (形) .

In its safe form, it can be used as a preventive tool for children or older adults, to understand the use of basic forces and assisted falls while moving, and for PD rehabilitation. *Gensoku-No-Genkei* requires high levels of perceptual, cognitive and adaptive processes such as attention, concentration, postural control, co-ordination with a partner and bilateral execution, which facilitates cognitive processing and slows the degradation of movement in PD.

Recent studies have demonstrated important brain connections for judo (Wantuir et Jacini, 2007; Wantuir et al. 2009). Young judoka show a different fractional anisotropy of white matter when compared with healthy people, which means that judo practice influences the brain for better connectivity between different areas (Toh et al., 2018).

The largest-ever clinical study of Parkinson's suggests that people with PD perform at least 2.5 hours of exercise every week for a better quality of life. (Jankovic et Tolosa, 2015). Another study showed that training two or three times a week is the best dosage for PD; in fact, training subjects with PD five days a week seems ineffective, as no improvement was observed. (Auxiliadora de Paula Vasconcelos 2020).

An exercise programme must include a tailored recovery time to help manage the PD symptoms. Many types of exercises can be performed, such as running and walking, biking, tai chi, yoga, pilates or dance, weight training, and non-contact boxing (Keus et al., 2014). Motor control function is also known. Although we understand some of these aspects, the full subtleties are yet to be explored. For example, the Substantia Nigra contains a large number of neurones that contain neuromelanin. Its main function is to produce dopamine, a crucial neurotransmitter for motor and movement control, cognitive executive function and emotional limbic activity (Ken Hub- Anatomy Substantia Nigra n.d.). Degeneration of this structure leads to Parkinson's syndrome (WHO -Parkinson disease n.d.). The interplay between Purkinje cells and the Substantia Nigra involves reward processing, motor control and cognitive functions (Kostadinov et Hausser, 2022) Further research is required to determine the intricacies of this interaction. A recent paper, the first study to explain the neurophysiology of transition in motor control networks, demonstrated the transition in connectivity between motor-related areas, according to movement states. Specifically, during the motor planning state, connectivity increased in most motor-related areas (Yeom et al., 2020)

Movement and exercise can have a significant impact on the substantia nigra in individuals with Parkinson's. Research has shown that exercise can help improve the functionality of dopaminergic neurons in the substantia nigra, which are crucial for motor control and are progressively lost in Parkinson's. One study showed an increase in dopamine transporter availability in the substantia nigra and striatum. This suggests improved functionality of the remaining dopaminergic neurons and an increase in neuromelanin concentration in the substantia nigra, which is associated with healthier dopaminergic neurons (de Laat et al., 2024).

Exercise also has neuroprotective effects that induce the activation of neurotrophic factors, such as brain-derived neurotrophic factor (BDNF) and nuclear factor (erythroid-derived 2)-like 2 (NRF2), which help protect neurons from oxidative stress and ferroptosis, a type of cell death. This can slow the progression of Parkinson's disease (Thirupathi et al., 2024) Furthermore, regular, moderate to high intensity exercise has been shown to ameliorate motor symptoms in Parkinson's patients, likely due to the neuroprotective and neurorestorative effects on the substantia nigra. (Palasz et al. 2019). Such information might help to uncover complex mechanisms, which gives hope regarding the potential benefits of movement interventions in PD, using more complex structures such as *Gensoku*.

CASE STUDY

Before starting the study case, the subject received sufficient and complete information about the potential risks and benefits of treatment through the Informed Consent Module.

Patient profile: RF, a retired, 66-year-old, height 1.65 m, weight 87 kg, practising judo since 1970, 2020 5th dan black belt.

Symptoms: Parkinson's akinetic form with high lateral torsion (~14°), Pisa Syndrome (Etoorn et al., 2020) and balance issues.

Intervention: Patient received physiotherapy, including *Gensoku no Genkei* as tori (executing techniques) and *uke* (receiving the techniques), from the left and right sides, a 9-week follow-up.

Outcomes: These outcomes provide insights into special rehabilitation management for Parkinson's. This single case study highlights the importance of more complex and bilateral physical activity and treatments in minimising and delaying the progression of symptoms in patients with Parkinson's.

History of present illness (HPI): Diagnosis of Akinetic Parkinson's Disease 28.2.2023, left-hand tremor (~5 months), decreased balance (~1 year), and Pisa Syndrome (Etoorn et al., 2020).

Past medical history included: Complete left brachial block 16.11.2019, and left convex roto-scoliosis of the distal lumbar spine.

Medications: He received a prescription and training for 'Levadopa,' reduced at his request (he does not believe that he needs additional doses).

Health habits: Non-smoker, occasional moderate alcohol consumption.

Current functional status: Since the onset of PD symptoms, he stopped every gymnastic or judo application for 16 months, with a dramatic worsening of his body's condition. He drives when necessary but with two safety belts and is less confident with reaction time. He is less confident walking outside, has problems with stairs and problems with bed mobility.

The timely execution of the proposed protocol, varied appropriately in the presence of critical issues that were gradually identified, highlighted a significant improvement in the initial functional state. Currently, he only wears the seatbelt required by law and his driving posture is improved. To walk outside and around the house, he needs the help of a walking stick or typical walker. He is still tiring to go up and down stairs and dress. There is improvement in his mobility in bed and showering but with slow movement.

PROTOCOL RATIONALE

The rationale of the protocol is based on the use of *Gensoku*, given its similarities to classic exercises for Parkinson's Disease (Abraham, 2022; Smith, 2019). See Figure 1.

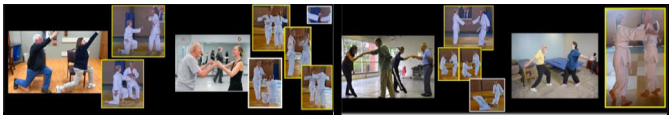


Figure. 1 Similarities between Parkinson's exercises and *Gensoku*

For Parkinson's affected patients, it is recommended to train on both sides, therefore performing *Gensoku No Genkei*, as *tori* and *uke*. *Gensoku* is carried out twice a week with recovery and warm-up based on the literature, which indicates that physical therapy distributed twice a week is effective for patients with Parkinson's Disease (Auxiliadora de Paula Vasconcelos, 2020). We also experimentally verified that a high dose of exercise, without adequate recovery, deteriorates performance.

A problem with evaluating the effectiveness of *Gensoku* objectively, quantitatively and without wearable instruments that are cumbersome and annoying to the subject was solved using video. We filmed all executions and evaluated their global time, various partial times (e.g. time to get up from the ground after falling), and the times of some classic and new tests. We also measured Pisa Syndrome deviation, testing if there were any benefits or changes over time.

Therefore, the optimal rhythm was found by having the subject performing *Gensoku* as *tori* and *uke* twice a week, on the right one day and on the left on the other. Previously, we tried one day as *tori* on the right and left and the following day on the right and left as *uke* but the physical load was shown to be too unbalanced, causing excessive physical stress on the second day.

During another week, on a day of rest, the subject walked to reach the hospital therapy pavilion, where he received mild standard therapy. However, the overall effort from the long walk and mild therapy produced a significant deterioration in the performance of *Gensoku* the day after.

From our experiments, it is clear that the recovery time between exercises, in addition to being personalised, must also be appropriately modulated according to the Hoehn and Yahr scale (Zhao et al. 2010) and with PD evolution. The protocol provides a fixed frequency (once every week) for a series of Standard Fitness Tests (Rikli et Jones 2013), with the addition of specific judo tests to monitor variations. The two Standard Tests were the up-and-go test and the twenty metres walking test (Rikli et Jones 2013). The Specific Judo Tests were migi *yoko ukemi* (falling to the right side), *hidari yoko ukemi*, (falling to the left side) and *ushiro ukemi* (falling backwards), (Sacripanti, 1989). However, these tests are not evaluated as the time of falling but rather as the time taken to return to standing from the ground position.

Other tests were performed at the end of three months of experience: two batteries of six Senior Standard Tests and the self-screening 'Healthy Survey F-36' (G.L.O.B.E. fisioscience, 2022). After one month, the subjects performed *Gensoku* again, verifying the persistent improvement obtained. The standard weeks (Table 1) were as follows.

Table 1. *Gensoku* validation protocol utilised in this case study

EXECUTION PROTOCOL WITH GENSOKU NO KATA (Dose: Two Times A Week)			
FIRST DAY	SECOND DAY	ONCE A WEEK	EXCEPTION IF THE SUBJECT IS TIRED OR NOT ABLE TO PERFORM ALL THE SEAMLESS SEQUENCE
10 minutes of warm up Gensoku no kata as Tori (dx) Gensoku no kata as Uke (dx) 15 minutes of recovery in between	10 minutes of warm up Gensoku no kata as Tori (sx) Gensoku no kata as Uke (sx) 15 minutes of recovery in between. END OF THE WEEK	Two Standard tests 15 minutes of recovery Three judo Falling Tests 10 minutes cool down	If necessary, Gensoku performance as Uke can be split in two parts with five minutes of recovery, in between

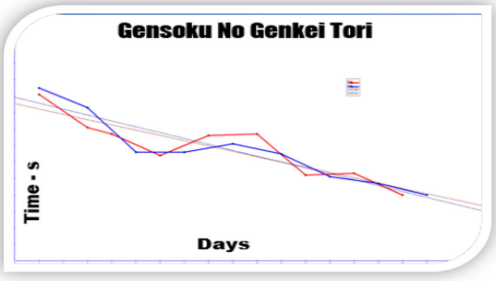
EXPERIMENTAL RESULTS

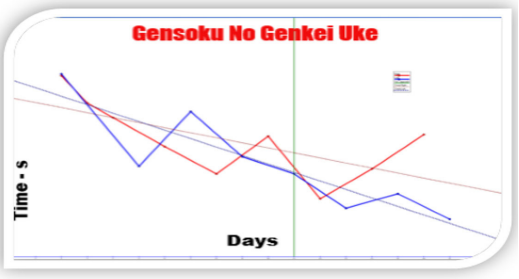
Gensoku evaluation

To develop an objective evaluation of the use of *Gensoku* as a tool to support the medical therapies used for Parkinson's Disease, it was decided after an appropriate and in-depth analysis to film the subject of the study and at different times deemed interesting for the purpose. The following tables show the data related to seven weeks of exercise (Table 2-7). Such data was graphed and analysed in order to identify the effects of *Gensoku*.

Table 2. *Gensoku* experiment times

TEST : gensoku no genkei Uke					
Date	Week	Test	Side	Value	Notes
05/10/2022	0	Tori	right	00:02:44	First stage of disease
05/02/2024	1	Tori	right	00:03:41	
05/02/2024	1	Tori	left	00:03:45	
07/02/2024	1	Uke	right	00:06:52	
07/02/2024	1	Uke	left	00:06:54	
12/02/2024	2	Tori	right	00:03:21	
12/02/2024	2	Tori	left	00:03:33	
12/02/2024	2	Uke	right	00:06:20	
12/02/2024	2	Uke	left	-	
19/02/2024	3	Tori	right	00:03:17	
21/02/2024	3	Tori	left	00:03:06	
19/02/2024	3	Uke	right	00:06:03	
21/02/2024	3	Uke	left	00:05:28	
26/02/2024	4	Tori	right	00:03:04	
28/02/2024	4	Tori	left	00:03:06	00:03:26 (Falled)
26/02/2024	4	Uke	right	00:05:29	
28/02/2024	4	Uke	left	00:06:10	
04/03/2024	5	Tori	right	00:03:16	
06/03/2024	5	Tori	left	00:03:11	00:03:26 (Falled)
04/03/2024	5	Uke	right	00:04:57	
06/03/2024	5	Uke	left	00:05:17	
11/03/2024	6	Tori	right	00:03:17	
18/03/2024	7	Tori	left	00:03:05	
11/03/2024	6	Uke	right	00:05:41	
18/03/2024	7	Uke	left	00:04:57	5 to 5 (mid rest)
20/03/2024	7	Tori	right	00:02:52	
		Tori	left		
20/03/2024	7	Uke	right	00:04:28	5 to 5 (mid rest)
		Uke	left		5 to 5 (mid rest)





Graphs 1. and 2. Times/ days *Gensoku* time and trends

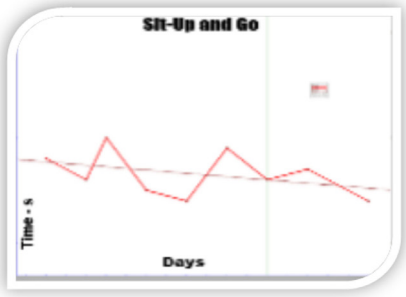
The decreasing trends in the graphs indicate that the subject tended to improve both the global execution speed and specific co-ordination during the execution of *Gensoku*.

Test evaluation

Similar to the classical tests, the trends showed an equally decreasing course, confirming slow but constant improvement.

Table 3. Classical tests times

Date	Week	Test	Side	Value	Notes
05/02/2024	1	sit up and go	-	00:00:18	3m distance
05/02/2024	1	walk test	-	00:00:26	20m distance
05/02/2024	1	fall and sit up	back	00:00:21	back up on favourite side
05/02/2024	1	fall and sit up	right	00:00:21	
05/02/2024	1	fall and sit up	left	00:00:27	
12/02/2024	2	sit up and go	-	00:00:16	3m distance
12/02/2024	2	walk test	-	00:00:21	20m distance
12/02/2024	2	fall and sit up	back	00:00:19	taken from gensoku (uke)
12/02/2024	2	fall and sit up	right	00:00:16	taken from gensoku (uke)
12/02/2024	2	fall and sit up	left	x	failed (excessive stress)
19/02/2024	3	sit up and go	-	00:00:20	3m distance
19/02/2024	3	walk test	-	00:00:20	20m distance
19/02/2024	3	fall and sit up	back	00:00:32	(right)
19/02/2024	3	fall and sit up	right	00:01:02	get up from weak leg (failed before)
19/02/2024	3	fall and sit up	left	00:00:26	
26/02/2024	4	sit up and go	-	00:00:15	3m distance
26/02/2024	4	walk test	-	00:00:18	20m distance
26/02/2024	4	fall and sit up	back	00:00:32	(right)
26/02/2024	4	fall and sit up	right	00:00:35	get up from weak leg
26/02/2024	4	fall and sit up	left	00:00:24	3m distance
04/03/2024	5	sit up and go	-	00:00:14	20m distance
04/03/2024	5	walk test	-	00:00:18	(right)
06/03/2024	5	fall and sit up	back	00:00:15	get up from weak leg
06/03/2024	5	fall and sit up	right	00:00:18	
06/03/2024	5	fall and sit up	left	00:00:12	First attempt: Failed
11/03/2024	6	sit up and go	-	00:00:19	Second Attempt: 00:00:26
11/03/2024	6	walk test	-	00:00:24	20m distance
11/03/2024	6	fall and sit up	back	00:00:28	(right)
11/03/2024	6	fall and sit up	right	00:00:34	
11/03/2024	6	fall and sit up	left	-	
20/03/2024	7	sit up and go	-	00:00:16	hands help (on chair)
20/03/2024	7	walk test	-	00:00:21	20m distance
20/03/2024	7	fall and sit up	back	00:00:15	(right)
20/03/2024	7	fall and sit up	right	00:00:12	
20/03/2024	7	fall and sit up	left	00:00:10	



Graphs 3 and 4. Times/ days classical tests time and trends

Table 4. Dx rise time

SURVEY OF RISE TIMES IN THE EXECUTION AS UKE (RIGHT AND LEFT)
WITH ANALYSIS ON THE IMPROVEMENT (NUMERIC AND %) TOTAL AND PER SINGLE FALL

(1) Values detected and calculated in seconds, hundredths of seconds (2) total times in minutes, seconds

EXECUTION		E.right 1	E.right 2	E.right 3	E.right 4	E.right 5	E.right 6	E.right 7	E.right 8	E.right 9	E.right 10
RIGHT		Single						in 2 parts			
	date	07-feb	12-feb	19-feb	26-feb	04-mar	11-mar	20-mar	27-mar	05-apr	10-apr
T	Tright1	19,00	36,51	17,29	15,96	18,98	21,46	11,66	19,80	16,68	16,68
e	Tright2	14,41	12,10	11,22	13,56	11,56	13,80	12,07	30,83	16,91	16,03
c	Tright3	21,42	14,17	16,85	11,22	11,80	16,10	13,83	13,25	18,47	13,68
h	Tright4	22,95	16,10	18,87	9,73	12,37	11,36	12,71	10,81	17,56	11,63
n	Tright5	20,61	16,91	17,05	12,41	10,71	16,34	11,73	12,07	22,17	15,52
i	Tright6	23,50	20,03	18,51	13,42	10,74	20,88	10,03	14,91	15,80	14,58
q	Tright7	22,64	16,47	18,13	12,61	16,71	20,85	8,61	11,52	17,39	14,30
u	Tright8	20,37	17,66	13,08	14,58	15,02	17,93	12,00	10,95	9,93	8,44
e	Tright9	22,57	19,35	16,44	15,86	12,58	15,02	8,51	12,74	20,03	14,30
	Tright10	16,27	19,83	15,15	15,90	16,03	20,64	10,88	14,00	31,25	14,78
	VALUES:										
(2) -	TOTAL	3,23	3,09	2,42	2,15	2,16	2,54	1,52	2,31	3,06	2,20
(1) -	MEDIUM	20,37	18,91	16,26	13,53	13,65	17,44	11,20	15,09	18,62	13,99

Table 5. Sx rise time

EXECUTION		E.Left 1	E.Left 2	E.Left 3	E.Left 4	E.Left 5	E.Left 6	E.Left 7	E.Left 8
LEFT		Single				in 2 parts			
	date	07-feb	21-feb	28-feb	06-mar	18-mar	25-mar	03-apr	08-apr
T	Tleft1	28,30	13,19	32,25	25,12	11,05	11,76	18,91	8,30
e	Tleft2	34,84	10,20	12,00	12,13	11,86	9,86	11,36	10,91
c	Tleft3	19,05	11,42	21,49	10,95	8,27	11,29	12,64	9,63
h	Tleft4	20,41	10,95	17,56	10,74	14,17	9,25	14,61	9,73
n	Tleft5	16,24	16,07	16,30	17,76	11,60	10,41	11,76	12,68
i	Tleft6	18,47	18,74	19,05	13,97	9,96	9,42	8,24	8,34
q	Tleft7	18,10	16,85	14,34	15,39	11,97	13,86	8,27	8,34
u	Tleft8	24,64	17,56	18,61	17,52	13,86	14,13	9,36	14,44
e	Tleft9	20,10	17,12	15,66	13,80	14,34	9,56	10,74	9,25
	Tleft10	18,52	17,32	19,69	13,12	32,00	15,05	16,88	14,71
	VALUES:					ATTILIO			
(2) -	TOTAL	3,38	2,29	3,07	2,35	1,52	1,54	2,02	1,46
(1) -	MEDIUM	21,87	14,94	18,70	15,05	13,91	11,46	12,28	10,63

Tabels 6. and 7. Rise time for *Gensoku* as uke

RIGHT — **DATA ANALYSIS**

NUMERICAL AVERAGE			best % reference to maximum		
General	Single	2 Parts	[*] (M-m)/M	Single	2 parts
19,40	21,53	16,21	68%	56%	41%
15,25	12,78	18,96	64%	22%	61%
15,08	15,26	14,81	48%	48%	28%
14,41	15,23	13,18	58%	58%	38%
15,55	15,67	15,37	52%	48%	47%
16,24	17,85	13,83	57%	54%	37%
15,92	17,90	12,96	62%	44%	50%
14,00	16,44	10,33	59%	36%	30%
15,74	16,97	13,90	62%	44%	58%
17,47	17,30	17,73	65%	27%	65%

How much in % does it improve total time to get up **53%**
How much in % does it improve average time to get up **45%**
[*] (Maximum value - minimum value)/ Maximum value

LEFT — **DATA ANALYSIS**

NUMERICAL AVERAGE			best % reference to maximum		
General	Single	2 Parts	[*] (M-m)/M	Single	2 parts
18,61	24,72	12,51	74%	59%	56%
14,15	17,29	11,00	72%	71%	17%
13,09	15,73	10,46	62%	49%	35%
13,43	14,92	11,94	55%	47%	37%
14,10	16,59	11,61	41%	10%	18%
13,27	17,56	8,99	57%	27%	17%
13,39	16,17	10,61	54%	21%	40%
16,27	19,58	12,95	62%	29%	35%
13,82	16,67	10,97	54%	31%	35%
18,41	17,16	19,66	59%	33%	54%

How much in % does it improve total time to get up **57%**
How much in % does it improve average time to get up **51%**
[*] (Maximum value - minimum value)/ Maximum value

In the next table (8), the best, the worst and the average time of *Gensoku* performance, and date from the tests carried out in Table 9, are compared, to best evaluate improvement obtained.

Table 8. Best, worst and mean performance obtained in the tests

Tests	Side	Best (m)	Date	Worst (m)	Date	Mean(m)
Gensoku no Genkei Tori	right	2.40	05/04/2024	3.41	05/02/2024	3.09
	left	2.40	08/04/2024	3.45	05/02/2024	3.07
Sit up and go	-	0,14	08/04/2024	0.20	19/02/2024	0.16
Walk test	-	0.18	04/03/2024	0.26	05/02/2024	0.20
Fall and get up	back	0.12	03/04/2024	0.32	19/02/2024	0.21
	right	0.12	20/03/2024	1.02	19/02/2024	0.25
	left	0.09	03/04/2024	1.35	10/04/2024	0.29
Gensoku No Genkei Uke	right	4.28	20/03/2024	6.52	05/02/2024	5.37
	left	4.04	08/04/2024	6.54	05/02/2024	5.12

Therefore, for *Gensoku* on right and left, we obtain practically the same average increase in co-ordination

Table 9. Improvement percentage after three month

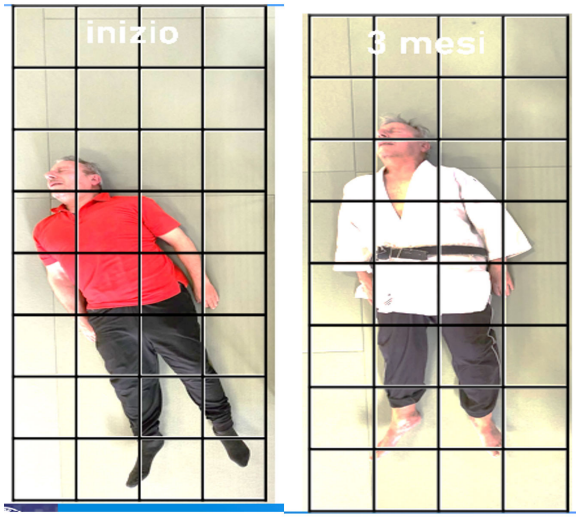
Gensoku No Genkei				
as Tori				
	Right	**best/ worst 29.6%**	**best / average 22%**	**average/ worst 9%**
	Left	**best/ worst 30%**	**best / average 21.8%**	**average/ worst 11%**
as Uke				
	Right	**best/ worst 34%**	**best / average 20%**	**average/ worst 17%**
	Left	**best/ worst 38%**	**best / average 21%**	**average/ worst 21%**
Tests Performed				
	Sit up and go	**best/ worst 20%**	**best / average 12%**	**average/ worst 20%**
	Walk	**best/ worst 30%**	**best / average 10%**	**average/ worst 23%**
Judo fall and get up				
	Back	**best/ worst 62%**	**best / average 42.8%**	**average/ worst 34%**
	Right	**best/ worst 88%**	**best / average 52%**	**average/ worst 75%**
	Left	**best/ worst 93%**	**best / average 64%**	**average/ worst 78%**

Pisa Syndrome (PS) (Harpreet et al., 2004; Tinazzi et al., 2016; Mimura et al., 2020) is a rare, reversible neurological disorder characterised by sustained muscle contractions that lead to abnormal posture and body twisting. In our case, lateral bending of the trunk tended to lean towards the right side. PS is a common and often disabling complication of Parkinson's..

Although no consistent diagnostic criteria for PS are available, most investigators have adopted an arbitrary cut-off of 10° lateral flexion for diagnosis. However, the mechanisms underlying PS have not yet been fully elucidated. Several drugs, including anti-Parkinsonian drugs, have been reported to induce PS. PS can cause severe and irreversible mechanical constraints affecting respiration, mobility and postural stability of the affected subject.

In our case study, the subject showed Pisa Syndrome with torsional, lateral bending on the right side of 14°.

After three months of *Gensoku* application, 10 complete executions, as *tori* and *uke*, PS decreased to 11° without any specific previously reported medical trials.



Figures 2. and 3. Before and after 3 months

Senior Fitness Tests (Rikli et Jones 2013), SFT were used in multiple areas. Given that the exercises require minimal equipment and space, (a larger space is required for the 6-minute walk test), we used an alternative exercise (the 2-minute step-in-place test), which can be used in smaller environments.

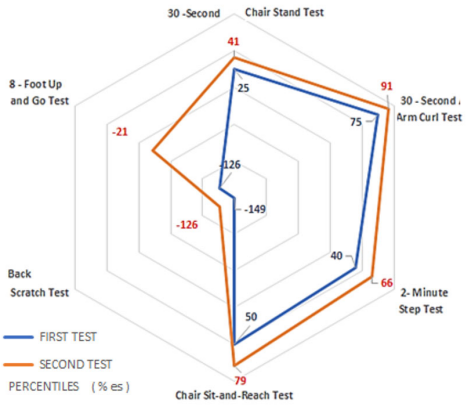
However, the collected data was not compatible with the reference tables and the only way to compare the data was to translate the findings into percentiles.

Subsequently, the verifiable improvements by the radar graph were calculated in the summary table. Specifically, the improvements are: Leg strength and resistance 16%, Arm strength and resistance 16% global resistance 28%, flexibility 29%, arm mobility 23%, agility 105%.

Table 10. Senior Fitness Test (Rikli & Jones, 2013) and Graph 5 show improvement in the body's muscular tone (Rikli & Jones, 2013)

Senior Fitnes Test Result

N.	TEST		FIRST TEST PERCENTILES (% es)	SECOND TEST PERCENTILES (% es)	WHAT IT MEASURES
1	30 -Second Chair Stand Test		25	41	LEG STRENGTH AND ENDURANCE
2	30 - Second Arm Curl Test		75	91	ARMS STRENGTH AND ENDURANCE
3	2- Minute Step Test		40	66	GLOBAL RESISTANCE
4	Chair Sit-and-Reach Test		50	79	FLEXIBILITY'
5	Back Scratch Test	-	149	-126	ARMS MOBILITY
6	8 - Foot Up and Go Test	-	126	-21	AGILITY



TEST	First TEST			Second TEST			DATA COLLECTION AND % es CALCULATION				REFERENCES % es AND RELATED INDICATORS				DIFFERENCE		
	Below average < 25% th	Average 25 -75 %th	Above average > 75% th	Below average < 25% th	Average 25 -75 %th	Above average > 75% th	Test results 1	% es calculated 1	Test results 2	% es calculated 2	1 % es	25 % es	75 % es	100 % es	PERCENTILE	NUMERIC	unit of measure
1		1			1		12	25	14	41	9	12	18	21	16%	2	Qt.
2		1				1	21	75	23	91	12	15	21	24	16%	2	Qt.
3		1			1		95	40	111	66	72	86	116	131	26%	16	Qt.
4		1				1	0	50	3,5	79	-6	-3	3	6	29%	3,5	Cm.
5	1			1			-30	-149	-27	-126	-11	-8	-1	2	23%	-3	Cm.
6	1			1			660	-126	365	-21	338	307	243	211	105%	-295	Sec.

REFERENCE : TEST 1 20/1 TEST 2 1/4 Average percentile improvement 22% Unconsidered

SF-36 (Short-form 36 items Health Survey) (GLOBE fisioscience, 2022) is a questionnaire on the state of health, characterised by brevity (on average, the subject takes no more than 10 minutes for completion) and precision (the tool is valid and reproducible). Born from the Medical Outcome Study (MOS), it was prepared for a population with chronic health problems, including the elderly. There are many versions of the MOS that are best known as the short form of 36 items, called SF-36, which contains eight of the 40 dimensions considered in the primary study, divided into 36 questions. All SF-36 questions, except one, refer to a period of four weeks preceding the completion of the questionnaire. The 36 questions conceptually refer to eight health domains and a single demand for change in the state of health (CS):

Table 11. F-36 Data analysis (GLOBE 2022)

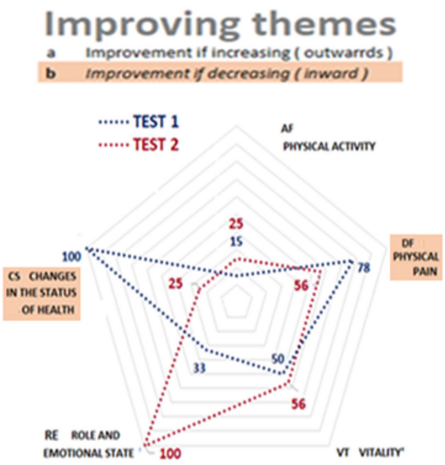
DATA ANALYSIS - GRAPHICAL REPRESENTATION - DATA TRANSFORMATION LOGIC

Medical Outcomes Study (MOS) 36-Items Short-Form Healthy Survey SF-36

QUESTIONNAIRE DATA PROCESSING

No. 00000 04/02/1957

theme song	description	refer back to me	Percentile (%) TEST 2	Percentile (%) TEST 1	points TEST 2	points TEST 1
AF a	PHYSICAL ACTIVITY Improvement if increasing	MAX 30 MIN 10 MED 20	25 %	15 %	15	13
RF a	PHYSICAL HEALTH ROLE Improvement if increasing	MAX 8 MIN 4 MED 6	0 %	0 %	4	4
DF b	PHYSICAL PAIN *Improvement if decreasing*	MAX 11 MIN 2 MED 7	56 %	78 %	7	9
SG a	HEALTH IN GENERAL Improvement if increasing	MAX 25 MIN 5 MED 15	75 %	75 %	20	20
VT a	VITALITY' Improvement if increasing	MAX 24 MIN 6 MED 15	56 %	50 %	16	15
AS a	SOCIAL ACTIVITY Improvement if increasing	MAX 10 MIN 2 MED 6	63 %	63 %	7	7
RE a	ROLE AND EMOTIONAL STATE Improvement if increasing	MAX 6 MIN 3 MED 4,5	100 %	33 %	6	4
SM a	MENTAL HEALTH Improvement if increasing	MAX 36 MIN 6 MED 21	53 %	53 %	22	22
CS b	CHANGES IN THE STATUS OF HEALTH *Improvement if decreasing*	MAX 5 MIN 1 MED 3	25 %	100 %	2	5



Graph 6. Improving information (GLOBE 2022)

The analysis of the extent of the improvements is as follows:
- by an increase in the percentile value (towards the external limit in the previous radar graph):
  AF PHYSICAL ACTIVITY from 15 to 25 with an improvement of 10%
  going from JUST ABOVE THE MINIMUM to BETWEEN MINIMUM AND AVERAGE
  VT VITALITY' from 50 to 56 with an improvement of 6%
  going from ABSOLUTE AVERAGE to JUST ABOVE AVERAGE
  RE ROLE AND EMOTIONAL STATE from 33 to 100 with an improvement of 67%
  going from ALMOST MEDIUM to ABSOLUTE MAXIMUM

by decreasing the percentile value (towards the centre of the previous radar graph):
  DF PHYSICAL PAIN from 78 to 56 with an improvement of 22%
  going from BETWEEN AVERAGE AND MAXIMUM to JUST ABOVE AVERAGE
  CS CHANGES IN THE STATUS OF HEALTH from 100 to 25 with an improvement of 75%
  going from ABSOLUTE MAXIMUM to BETWEEN MINIMUM AND AVERAGE

			T 2%ile	T 1%ile	Δ %es
physical state	AF	PHYSICAL ACTIVITY	25	15	10
	RF	PHYSICAL HEALTH ROLE	0	0	0
	DF	PHYSICAL PAIN	56	78	-22
	SG	HEALTH IN GENERAL	75	75	0
mental state	VT	VITALITY'	56	50	6
	AS	SOCIAL ACTIVITY	63	63	0
	RE	ROLE AND EMOTIONAL STATE	100	33	67
	SM	MENTAL HEALTH	53	53	0
	CS	CHANGES IN THE STATUS OF HEALTH	25	100	75

In summary

			Δ
physical state	39%	42%	3%
%es	156	168	
mental state	68%	50%	18%
%es	272	199	

Note: determination of the percentage value (%) from the sum of the percentiles (%es) of the domain : [% = ∑%es / 400]

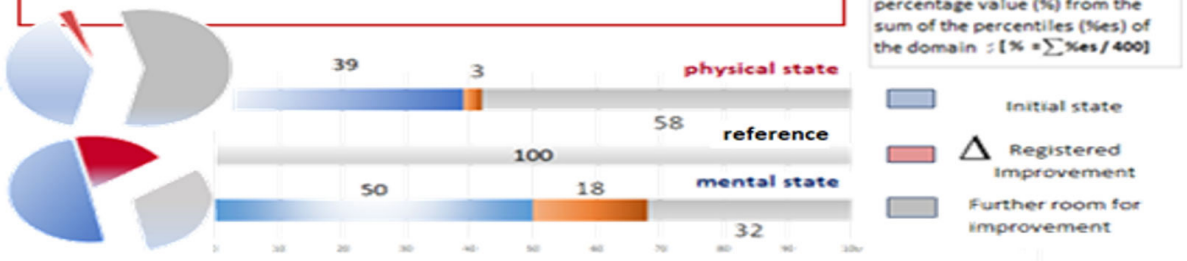


Table 12. F-36 and Figures 4. and 5. improvement evaluation. (GLOBE 2022)

FORMAT DAY (original evaluation analysis)
The original fomat was prepared to analyse the effects of *Gensoku* performance to highlight any counter-productive effects; the state was described by the study case volunter.

FORMAT DAY		PAIN														TIREDNESS															
		AFTER				EVERING				NIGHT				MORNING				AFTER				EVERING				NIGHT				MORNING			
PHYSICAL STATE	RIGHT ARM	1	1	1		1	2	1			1			2	2			2		1	2	2			1					2			
	LEFT ARM					0												1		1	2	1			1					1			
	NECK			1		0	1	1			1	1			1			1		1	2	1			1			1					
	CCHEST	1				1												1		1	2	1			1							
	BACK	2			2	2												2		1	2	2			1					2			1
	ABDOME	1				1	1				1				1			1		1	2	1			1					2			
	BUTTOCKS					0	1				1				1			0		1	2	0			1								
	RIGHT LEG	1	1	1		1	2	1			1				2	2		2		1	2	2			1					2		2	1
	LEFT LEG	1			1	1												2		1	2	2			1					1			
(a) 09/03/2024 - (b) 11/03/2024		(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
(c) 18/03/2024 - (d) 19/03/2024	(Note) Enter: 0 = none; 1 = negligible; 2 = important; 3 = unbearable.																																

Table 13. Format Day data (original)

“Pain, mostly localised in the right arm, neck, back and right leg, recorded throughout the day (after training, in the afternoon, at night and in the morning of the following day), from negligible to significant, became absent with the exception of the back and of the right leg, always present after training. The generalised tiredness over the whole body, always presented as negligible or important after training, initially slowly eased until it disappeared, and subsequently, the process became faster. Even the tiredness, as reported for the pain, although easing, remained in the back and right leg.” All this is in line with the result reported for the DF PHISICAL PAIN domain (SF-36).

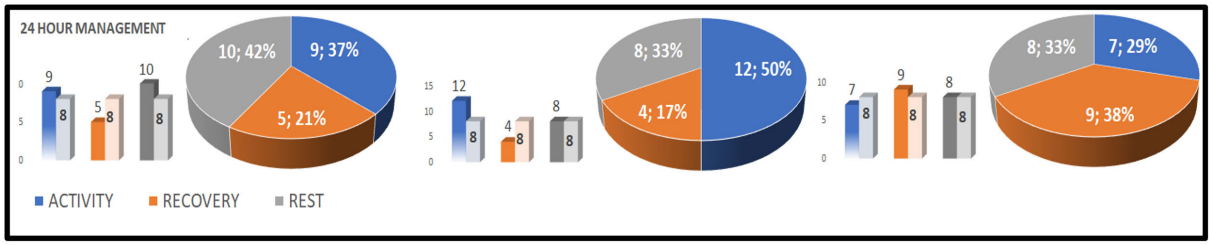
LOCOMOTION	STEPS								AMOUNT	EQUILIBRIUM								TODAY HOURS											
	NUMBER				RHYTHM					STATIC				DYNAMIC				ACTIVITY				RECOVERY				REST			
	2ND		nd		1		3	3		2	2	1	3	1	3	1	3	9	12	7	7	5	4	9	9	10	8	8	8
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)		(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
(Note) Enter: 0 = good; 1 = sufficent for improvement; 2 = sufficent but constant; 3 = got worst.																													

Table 14. Locomotion and equilibrium data (GLOBE 2022)

The data reported on the format day was not comforting data regarding locomotion and balance, in contrast to what was detected during the gym tests, where improvements were evident and documented.

This leads to the sole deduction that the participant must modify the rhythms of daily life by appropriately alternating activity times with adequate rest. Planning of daily work with the right recovery times for longer or heavier work, in line with the logic contained in the execution protocol and the awareness of accepting no activities above one's own forces, can make a subject's life less tiring, more manageable, and less painful.

Figure 6. Example of % distribution of activities during the days 09/03/2024, 11/03/2024, and 18-19/03/2024.



Pie chart referring to the % distribution of activities during the day. Bar graph of hours of activity during the day in relation to the 8-8-8 type distribution.

RESULTS DISCUSSION

Comparison with previous research

To the best of our knowledge, there are very few applications of judo specifically for Parkinson's Disease, with no execution of the falling technique. (Sakuyama et al., 2021). While much research has been conducted on the benefits of physical exercise in people with Parkinson's Disease, specific studies focusing on judo are not as common. Music and dance therapy can alleviate freezing gait. Several studies have demonstrated the successful use of integrative strategies for improving patient accessibility and participation. (Rafferty et al. 2021). Some studies have highlighted the potential benefits of judo training for brain function related to physical and cognitive performance in older adults (Adler & Ahlskog, 2000). Judo, as an open-skill discipline, requires excellent cognitive function, such as executive function, processing speed, working memory, and learning, in addition to excellent physical ability to adapt to a continually changing environment (Sacripanti, 2021). All these aspects could help improve motor skills and cognitive function in individuals with Parkinson's.

Discussion

The results clearly support the initial hypothesis that *Gensoku-No-Genkei* can be used as a therapeutic tool for functional improvement in patients with PD, even in an advanced state. The confirmation can be deduced quantitatively from the results and trends of the graphs which clearly show a decrease in the general execution time (Graphs 1. and 2.). This is also confirmed by the times for standing up from the right and left falls (Tables 2. and 3.), which show an interesting time percentage decrease of the total 10 falls of *Gensoku*, both as a total time and average time: 53% and 45% on the right and 57% and 51% on the left, respectively.

Interestingly, the improvements between the global best and worst times of *Gensoku* as tori are very similar to those of *uke*; there is a little prevalence of left on the right; 34% vs 38%. The slight but consistent better result of the left over the right side is due to the roto-flexion of PS accentuated towards the right side, which implies a weakening of the muscles acting under unnatural angles. The results were also supported by the tests performed for both the classic tests (Graphs 3.and 4.) 'sit up and go' and 'walk for 20 metres' and the judo falls tests. In addition, PS was improved by bringing the lateral roto-flexion from the previous 14° to the current 11° (Figures 2. and 3.) without any specific treatment.

Strengths

Regarding the follow-up assessment of pain after the execution (Format Day), an improvement was observed, with pain eventually subsiding in some cases (see Table 13). Mood and cognitive impairments associated with Parkinson's disease did not deteriorate, according to the self-analysis results (Tables 9. and 10.). This study demonstrates that the judo sequence *Gensoku-No-Genkei* may be efficacious as a therapeutic tool for individuals with Parkinson's disease. The patient exhibited significant improvement in balance, co-ordination, and reduction of Pisa Syndrome symptoms.

Limitations

This exploratory study, conducted for the first time and developed as a single case study (Gerring, 2006), aimed to evaluate the potential efficacy of a judo sequence called *Gensoku-No-Genkei* as a therapeutic tool for Parkinson's Disease.

Several limitations of this pilot study are inherent to its nature, as a single case study, which restricts the generalisability of the results. For instance, the absence of a control group impedes the comparison of results and the assessment of the therapy's effectiveness beyond this individual case. Additional limitations include: the reliance on subjective patient evaluation, which may introduce bias in the assessment, and the absence of objective medical analysis of the subject during the experimental phase. Moreover, the study did not incorporate long-term follow-up of the patient post-intervention. These identified limitations can be addressed through further research involving larger samples, control groups and long-term follow-up assessments.

Theoretical Implications

This approach shows the potentially profound impact of judo on Parkinson's patients and sheds light on an innovative approach. In addition to the well-known cardinal symptoms (Albin & Roger, 2022), there is a loss of spontaneous movement, a reduction in blinking, a marked reduction in facial expressions, a lowering of the vocal tone and a change in writing that tends to become smaller. Motor symptoms can exhibit asymmetric presentation (Albin & Roger, 2022) and *Gensoku* as a therapeutic tool can address and improve movement alterations through the adjustment of dysfunctions in the musculoskeletal system, possibly utilising well-known brain plasticity.

Practical Implications and future direction

If the validity of *Gensoku* is confirmed, after more complete scientific investigations, it could be added to the already rich system of existing therapeutic and rehabilitation methods. However, *Gensoku* seems to have many more advantages than conventional treatments accepted and employed today.

Wider and more complete multidisciplinary research on a wider base of subjects with Parkinson's Disease.

CONCLUSION

Gensoku as a therapeutic tool can elicit the following physiological responses:

Increased strength and muscular endurance, pain reduction potentially attributable to decreased inflammation, and enhanced tissue relaxation. These effects contribute to an improvement in overall physical condition.

The outcomes may vary depending on the stage of Parkinson's Disease and the reactive capacity of the individual. Based on this quantitative experimental study and its results, it can be concluded that *Gensoku-No-Genkei*, conceptualised as complex bilateral training for patients with PD, when appropriately dosed over time and interspersed with adequate recovery periods, positively stimulates neuro-plasticity in patients with PD.

Gensoku-No-Genkei, when implemented correctly, contributes to the deceleration of symptoms and, more significantly, to a partial recovery from global motor deterioration. This has substantial implications for patients' activities of daily living. Consequently, judo can be considered an effective complementary tool to support medical therapy for patients with Parkinson's Disease. This assertion was corroborated by the collected quantitative data. The identified limitations can be addressed through further research involving larger samples, control groups and long-term follow-up assessments. Additional and more comprehensive studies, conducted in accordance with accepted scientific principles and controlled experiments, are therefore necessary to provide a more definitive evaluation of these claims.

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Relationship Between Toe Grip Strength and Injury in Judo Athletes

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Abstract: *This study compared toe grip strength of injured and non-injured male judo athletes (5 and 21 subjects, respectively). Toe grip strength was measured by replacing the digital hand grip strength meter with the toes. The grip strength of the toes was measured by gripping a bar with multiple toes from first to fourth toe. Toe grip strength was measured in sitting and standing positions, in the order of right, left and both feet, twice on each site, with the higher value being used as the measured value.*

The measurements of toe grip strength in sitting position were 28.4±9.7 kg and 32.7±5.6 kg in the injured group and the non-injured group, respectively. These measurements were considerably higher than those of healthy subjects. Next, a comparison between the injured group and the non-injured group revealed that measurements in sitting position were lower, although not significant, in the injured group for all measurement items. In addition, the injured group showed a significant difference from the non-injured group in left foot measurements and in Relative Absolute Difference between right and left feet. These results suggest that judo athletes with lower limb injury may have lower toe grip strength and greater Relative Absolute Difference between right and left feet.

Keywords: *judo athletes; toe grip strength; injury; Relative Absolute Difference*

Grip strength in the hands has long been recognised as a physical fitness measurement. On the other hand, the grip strength of the toes is not well-known in terms of its measurement and has not received much attention. However, in recent years, a device that can easily measure toe grip strength has been developed (Fukumoto et al., 2011) and since then research reports in various fields have been observed. Nevertheless, standard values for so-called toe grip strength have not yet been established and only a few reference averages, such as those reported by Uritani et al. (2014), are available. As a result, toe grip strength has not become a standard measurement item like hand grip strength.

The reason for focusing on toe grip strength lies in its connection to daily life activities, sports performance and injury. For example, from a rehabilitation perspective, toe function affects balance (Hori et al., 2008; Takeda et al., 2009; Kelly and Stanek, 2020; Murata, 2004) and is related to posture (Hasegawa et al., 2013; Kabe et al., 2002; Hanada et al., 2004). Additionally, it has been reported that toe grip strength impacts the likelihood of falls, and training to enhance this strength is effective in fall prevention (Kito et al., 2001; Murata et al., 2007; Ueda et al., 2019) . Thus, maintaining good toe function can help prevent a decline in activities of daily living (ADL) and quality of life (QOL) while also improving them (Uritani et al., 2015; Yoshida et al., 2023; Tsuyuguchi et al., 2019; Mawarikado et al., 2023) .

Recently, research on toe grip strength in sport has also become more common, with connections to performance being noted (Yamada and Sudo, 2015; Mitsui, 2019; Oishi et al., 2012; Yuasa et al., 2019). The authors have focused on the relationship between toe function and injuries, observing that a history of injuries manifests as differences in toe grip strength between the left and right sides (Oishi et al., 2012) . In sport there are events that primarily involve bilateral movements, those that involve unilateral movements, and those that mix both types. It is necessary to consider the impact of these characteristics. However, if asymmetries in toe function are related to injuries, they could provide a clue for injury prevention and early detection.

Many sports, except swimming, involve phases where the soles of the feet are in contact with the ground or where the soles are used to perform actions, such as pedaling in cycling. In martial arts like judo, kendo and sumo, practitioners stand barefoot on *tatami*, floors, or *dohyos*, making the function of the toes crucial. In judo, the toes are not

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only important for maintaining a standing position but also for gripping the tatami, pushing off the tatami and absorbing impact during breakfalls. Therefore, toe function can influence performance and necessitates caution to prevent toe-related injuries during daily practice and matches. However, as far as we know, there have been no studies reporting on toe function in judo.

In this study, we measured the toe grip strength of male university judo athletes engaged in specialised training and conducted a questionnaire survey on the presence of injuries. The purpose of this study is to investigate the relationship between toe grip strength and the occurrence of injuries in judo athletes and to gain new insights.

METHOD

Subjects

The subjects were male judo club members who were training professionally at university. Among them, those currently experiencing lower limb injuries, based on a questionnaire, were categorised as the injury group, while those without injuries were categorised as the non-injury group. The measurement of toe grip strength was conducted multiple times; however, individuals who could not properly grasp the bar of the measuring device with their toes or those who experienced pain when grasping the bar multiple times, thereby hindering the measurement, were excluded from this study. As a result, there were 5 subjects in the injury group and 21 subjects in the non-injury group.

The injury group had an average age of 20.0±0.7 years, 10.0±4.3 years of judo experience, a height of 170.6±6.1 cm, a weight of 86.2±17.2 kg, a BMI of 27.9±8.8, and a shoe size of 27.7±0.7 cm. The non-injury group had an average age of 20.1±0.9 years, 12.0±3.9 years of judo experience, a height of 171.5±6.7 cm, a weight of 86.3±19.8 kg, a BMI of 29.1±5.1, and a shoe size of 27.2±1.3 cm. The physical characteristics of both groups are shown in Table 1.

Table 1. Physical characteristics of Subjets

		Injured	No injuries	p-Value
N		5	21	
age	yr	20.0±0.7	20.1±0.9	p=0.63
Age of experience	yr	10.0±4.3	12.0±3.9	p=0.37
height	cm	170.6±6.1	171.5±6.7	p=0.63
body weight	kg	86.2±17.2	86.3±19.8	p=0.99
BMI	kg/m2	27.9±8.8	29.1±5.1	p=0.83
Foot size	cm	27.7±0.7	27.2±1.3	p=0.55

Informed Consent

The subjects undergo morphological measurements and physical fitness tests 1 to 2 times a year, with toe grip strength being one of the measurements conducted. The subjects were informed that this study would be conducted in accordance with the 'Ethical Guidelines for Medical and Health Research Involving Human Subjects' set forth by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare. Additionally, the significance and purpose of the study, the specific measurement methods, potential risks associated with the measurements, and the handling and management of data and personal information were explained both orally and in writing. Only those who expressed their willingness to participate in this study were included as subjects. This study was approved by the Ethics Committee of Tokai University (Approval No. 21069).

Measurement of Toe Grip Strength

Toe grip strength is the tension exerted during the flexion of the toes, involving muscles such as the flexor hallucis brevis, flexor hallucis longus, lumbrical muscles, and flexor digitorum brevis (Kawakami and Fukunaga, 2002). The measurement device used was the T.K.K. 3360 toe grip dynamometer manufactured by Takei Scientific Instruments Co., Ltd. This device works by fixing to the ankle with a band, and measuring the grip strength as the big toe, index toe, middle toe, and ring toe (three toes in some cases, depending on the foot's shape) grasp a bar (Photo 1).

Photo 1. Measurement of toe gripping muscle strength in a sitting position. Explaining the posture and method of measurement to the subject.

The subjects first measured their right foot, left foot, and both feet (simultaneously) twice each while in a seated position (sitting on a chair with knee joints at 90 degrees and ankle joints at 90 degrees). They were instructed to cross their arms over their chest and not to hold onto the chair or any other object. Next, the same measurements

(right foot, left foot, and both feet simultaneously) were performed, twice each, in a standing position (standing on two devices set at hip-width apart). In the standing position as well, the subjects were instructed to cross their arms over their chest (Photo 2). A total of six measurements were taken in both seated and standing positions and the highest toe grip strength for each was recorded as the measurement value.

Photo 2 Measurement of toe grasping muscle strength in a standing position. As in the sitting position, the upper limbs were crossed at the chest and measured.

Statistical Analysis

The numerical data was presented as means (± standard deviation). The toe grip strength measurements the injury group were compared between those of the non-injury group, both in terms of the raw measurement values and the differences between the left and right feet. The left-right difference was calculated using the following formula:

• (Difference in measurements) = (Measurement of the stronger foot) - (Measurement of the weaker foot)

The relative absolute difference (%RAD) was calculated using the following formula:

• %RAD = [(Measurement of the stronger foot) - (Measurement of the weaker foot)] / (Measurement of the stronger foot) * 100

The comparisons of the mean values and %RAD were conducted using an independent t-test. A significance level of less than 5% was considered statistically significant.

RESULTS

Table 2 presents the measurement results of toe grip strength in both sitting and standing positions for the two groups. The detailed results are shown separately for sitting and standing positions.

Table 2. Measurement results of the toe gripping force in both groups

			Injured	No injuries	p-Value
sitting position	right	kg	29.6±8.4	32.1±5.1	p=0.55
	left	kg	27.7±3.9	33.2±6.2	p=0.03
	average	kg	28.7±5.9	32.7±5.6	p=0.22
	Left-right difference	kg	4.9±2.5	2.2±1.6	p=0.07
	%RAD	%	15.8±7.7	6.2±4.0	p=0.04
	both foots (right)	kg	24.4±6.6	28.4±4.2	p=0.26
	both foots (left)	kg	23.2±4.0	27.4±5.2	p=0.09
	both foots (average)	kg	23.8±5.2	27.9±4.5	p=0.18
	Left-Right difference	kg	2.8±1.7	2.4±1.8	p=0.30
	%RAD	%	10.5±3.8	8.3±6.2	p=0.30
standing position	right	kg	27.6±9.7	32.7±5.9	p=0.36
	left	kg	29.1±10.0	34.5±8.5	p=0.31
	average	kg	28.4±9.7	33.6±8.5	p=0.32
	Left-Right difference	kg	3.0±2.1	4.2±3.6	p=0.25
	%RAD	%	13.3±9.9	11.2±7.0	p=0.77
	both foots (right)	kg	25.9±7.7	31.0±5.7	p=0.27
	both foots (left)	kg	24.7±6.8	31.5±6.2	p=0.09
	both foots (average)	kg	25.3±7.6	31.3±5.7	p=0.16
	Left-Right difference	kg	3.3±2.3	2.7±2.3	p=0.61
	%RAD	%	11.7±7.2	8.0±5.8	p=0.33

※： $p < 0.05$

Toe Grip Strength in Sitting Position

For the group with impairments, the toe grip strength measured individually for each foot in the sitting position was 29.6±8.4 kg for the right foot and 27.7±3.9 kg for the left foot, with an average of 28.7±5.9 kg. The left-right difference was 4.9±2.5 kg, and the percentage relative asymmetry difference (%RAD) was 15.8±7.7%. When measured simultaneously for both feet, the right foot showed 24.4±6.6 kg and the left foot showed 23.2±4.0 kg, with an average of 23.8±5.2 kg. The left-right difference was 2.8±1.7 kg, and the %RAD was 10.5±3.8%.

For the group without impairments, the toe grip strength measured individually for each foot in the sitting position was 32.1±5.1 kg for the right foot and 33.2±6.2 kg for the left foot, with an average of 32.7±5.6 kg. The left-right difference was 2.2±1.6 kg, and the %RAD was 6.2±4.0%. When measured simultaneously for both feet, the right foot showed 28.4±4.2 kg and the left foot showed 27.4±5.2 kg, with an average of 27.9±4.5 kg. The left-right difference was 2.4±1.8 kg, and the %RAD was 8.3±6.2%.

When comparing the two groups, the group without impairments showed higher values in the right foot, left foot, and the average of both feet. The left-right difference and the %RAD were lower in the group without impairments. The group with impairments showed significantly lower values for the left foot and %RAD in the individual measurements (each $p<0.05$).

Toe Grip Strength in a Standing Position

For the group with impairments, the toe grip strength measured individually for each foot in the standing position was 27.6±9.7 kg for the right foot and 29.1±10.0 kg for the left foot, with an average of 28.4±9.7 kg. The left-right difference was 3.0±2.1 kg and the percentage Relative Asymmetry Difference (%RAD) was 13.3±9.9%. When measured simultaneously for both feet, the right foot showed 25.9±7.7 kg and the left foot showed 24.7±6.8 kg, with an average of 25.3±7.6 kg. The left-right difference was 3.3±2.3 kg, and the %RAD was 11.7±7.2%.

For the group without impairments, the toe grip strength measured individually for each foot in the standing position was 32.7±5.9 kg for the right foot and 34.5±8.5 kg for the left foot, with an average of 33.6±8.5 kg. The left-right difference was 4.2±3.6 kg, and the %RAD was 11.2±7.0%. When measured simultaneously for both feet, the right foot showed 31.0±5.7 kg and the left foot showed 31.5±6.2 kg, with an average of 31.3±5.7 kg. The left-right difference was 2.7±2.3 kg and the %RAD was 8.0±5.8%.

When comparing the two groups, the group without impairments showed higher values in the right foot, left foot and the average of both feet, although none of these differences were statistically significant. The left-right difference was higher in the group without impairments when measured individually, but lower when measured simultaneously for both feet. The %RAD was consistently lower in the group without impairments. However, there were no significant differences observed for either the left-right difference or the %RAD.

DISCUSSION

Standing posture and walking movements are indispensable in daily life, with the soles and toes of the feet playing crucial roles in these activities. Therefore, toe function is deeply related to daily activities and is considered to influence overall health. Many studies on toe grip strength have been reported from a rehabilitation perspective; however, recent reports have also begun to focus on sport.

Mitsui (2019) conducted measurements on baseball players and demonstrated that the toe grip strength in the pivot leg during pitching and batting was significantly higher in pitchers than in fielders. Mitsui speculated that the pitching practice might have specifically strengthened the toe grip strength of pitchers' pivot legs when compared with fielders. This suggests that toe function develops through everyday training patterns and pitching movements. Yamada and Sudo (2015) examined the relationship between toe grip strength and 50-metre sprint performance under two conditions: barefoot and with shoes. They found a positive correlation in both conditions, indicating that toe grip strength is an important factor for sprinting ability. Additionally, Oishi et al. (2012) investigated the relationship between toe grip strength and injuries in rugby players. Their results showed that there were differences in toe grip strength between the left and right feet depending on the presence or absence of a history of injuries throughout the body.

These findings suggest that toe function (toe grip strength) is an important factor in sports performance. However, it is still unclear what specific roles toe function plays.

The subjects of this study were male university judo athletes who engage in intense daily training. First, let's consider the measurement results of toe grip strength in judo athletes. According to the report by Uritani et al. (2014), the average toe grip strength in the sitting position for men in their 20s is 16.9±6.0 kg. In comparison, the impaired group had an average toe grip strength of 28.4±9.7 kg and the unimpaired group had an average of 32.7±5.6 kg, both showing higher values. Yamauchi et al. (2012) reported on the effects of six weeks of running on grass on toe grip strength, showing a significant increase in toe grip strength (though no significant improvements were observed in the 20m sprint or standing long jump performance). This suggests that running barefoot contributed to the improvement in toe grip strength. Judo athletes also train barefoot on tatami and this training style is believed to be a factor that enhances toe grip strength.

In judo, the style of attack and defence is often dictated by the dominant hand, leading to frequent front and rear foot positioning. Therefore, as reported by Mitsui (2019), it is possible that one foot might have stronger toe grip strength. For the unimpaired group, in the sitting position, the right foot had a toe grip strength of 32.1±5.1 kg, the left foot had 33.2±6.2 kg and the percentage Relative Asymmetry Difference (%RAD) was a small 6.2±4.0%. This suggests that in various judo training activities, the two feet are used evenly without bias and the style of attack and defence dictated by the dominant hand does not affect the left-right difference in toe grip strength.

Next, we compared the toe grip strength in the sitting position between the impaired and unimpaired groups. The impaired group showed significantly lower values for the left foot and a significantly higher %RAD, indicating a larger relative difference between the left and right feet. This suggests that having an impairment in one leg results in a larger relative difference in toe grip strength. In judo, various techniques are executed with the soles of the feet in contact with the *tatami*. A left-right difference in toe grip strength (i.e., having an impaired leg) could impact many techniques and potentially decrease overall judo performance.

The results of this study indicate that the presence or absence of leg impairments increases the relative difference in toe grip strength. However, in the standing

position, no significant difference was observed in the relative difference. Nakae et al. (2013) reported that in measuring toe grip strength, the electromyographic activity of the medial gastrocnemius muscle was significantly higher in the sitting position than in the standing position. This suggests that a decrease in gastrocnemius muscle strength could lead to lower toe grip strength in the sitting position. This could explain why a significant difference in %RAD was observed in the sitting position but not in the standing position in this study. It is easy to imagine that leg impairments affect the tension exerted by the gastrocnemius muscle, leading to a decrease in toe grip strength in the sitting position and a larger relative difference in toe grip strength.

In judo, contests begin in a standing position and many techniques are executed from this position. This study found significant differences in two items related to toe grip strength in the sitting position but not in the standing position. Some subjects commented that they could exert more force with their toes in the standing position than in the sitting position. Further research is needed to examine toe function in the standing position from various perspectives.

Limitations and Practical Implications of This Study

The participants in this study consisted of 26 members of the judo club of a single university, with 5 in the injury group and 21 in the non-injury group. Given that training methods and the quality and quantity of practice can vary by team, it is necessary to conduct additional measurements involving judo athletes from multiple universities. This will allow for further examination based on the content of their training.

This study aimed to investigate the relationship between injuries and toe grip strength. However, it was not able to clarify whether strengthening toe grip strength or reducing the relative difference between the left and right sides could serve as a preventive measure against injuries. Future research should focus on how the training and improvement of toe grip strength affect injury prevention.

The results of this study indicated that injured athletes exhibited lower toe grip strength in a seated position and greater differences between the left and right sides. On the other hand, measurements in a standing position showed smaller differences between the left and right sides, suggesting that the athletes might still maintain or exhibit their performance during standing practices and contests. However, potentially, this could obscure lower limb injuries in judo practice and contests conducted in a standing position. This might lead to the exacerbation of injuries or extend the recovery period needed for complete healing.

The first practical implication is that a noticeable difference in toe function between the left and right sides could indicate the presence of lower limb injuries. The second implication is the necessity of having scales like toe grip strength to screen for lower limb injuries and to monitor the recovery process.

CONCLUSION

This study aimed to measure and compare toe grip strength in male judo athletes with and without impairments, to gain insights into their physical condition. The impaired group consisted of five athletes, while the unimpaired group included 21 athletes, all of whom were training at the university level.

Toe grip strength was measured twice each for right foot, left foot and both feet in both sitting and standing positions, with the highest value recorded as the measurement. In the sitting position, the toe grip strength measurements were 28.4±9.7 kg for the impaired group and 32.7±5.6 kg for the unimpaired group, both considerably higher than those for healthy individuals.

When comparing the impaired and unimpaired groups, the impaired group showed lower values consistently, although not significantly, in the sitting position. Additionally, the impaired group had a significantly lower measurement for the left foot and a significantly higher percentage Relative Asymmetry Difference (%RAD) compared to the unimpaired group. This indicates that judo athletes with lower limb impairments tend to have a greater left-right asymmetry in toe grip strength.

In the standing position, no significant differences were observed between the groups for any measurement item or in the percentage Relative Asymmetry Difference. This suggests that judo athletes with impairments or those in the recovery process can maintain performance during training and competitions conducted in a standing position, potentially masking the left-right asymmetry indicated by toe grip strength.

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