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Serious Sports Injuries of *Judoka* in Japan Including ACL injury, Head Injury, and Unconsciousness Via *Shime-Waza*

By Nobuhiro Kamiya[1,2,3], Isao Yoshida[2,3], and Oki Kazuhisa[2,3]

Abstract: *The purpose of this study was to investigate three serious conditions, ACL injury, head injury, and unconsciousness by shime-waza in collegiate judoka. In total 518 athletes (286 male and 232 female) were recruited with an average age of 19.7 ± 1.3 years, more than 10 years of judo experience (12.5 ± 2.8 year, and relatively high judo grade (2.0 ± 0.52). ACL injury was seen in 70 athletes (average 13.7%), in which 48 athletes (71.6%) received ACL reconstruction surgery. After athletes returned to competition, 45.0% recognised their performance as equal to pre-injury levels. The remainder had some concerns regarding physical functios (i.e. reductions in leg muscle power, core stability, knee range of motion, knee pain, etc). Out of 475 athletes, 148 had experience of head injuries (31.2%), in which concussion was the most frequent (83.1%). The judo grade (dan) at the time of head injury (1.24 ± 0.71) was significantly lower than that of the current grade (2.04 ± 0.51). After head injury, 45.2% of athletes returned to judo practice within the next day. The incidence of unconsciousness from shime-waza (59.1%) was similar to that of providing unconsciousness by shime-waza (57.4%). The judo grade (dan) at the time of unconsciousness by shime-waza (0.88 ± 0.60) was significantly lower than that of the current grade (2.02 ± 0.53). There was a significant correlation between the experience of head injury and unconsciousness by shime-waza. This study demonstrates the incidence and factors of serious injuries in judo and provides milestones to improve the environment of judoka.*

Keywords: *judoka; university; gender; knee; fainting; concussion*

Career length and injuries are associated (McLellan et al., 2022) because athletes often terminate their competitive careers due to a loss of physical function following sport-related injuries. Judo is one of the contact sports that could often cause sport-related injuries when compared with non-contact sports. In fact, we previously reported that judo caused the highest incidence of sport-related injuries (i.e. 106.4% per year, which means each *judoka* gets injured at least once a year) among more than 25 independent sports, over 5000 collegiate athletes (Kamiya et al., 2016). In our previous study, the incidence of joint sprain in *judoka* was the highest among sports (68.2%). Other reports demonstrated that sprain (Pocecco et al, 2013; Frey et al., 2019), ligament (Blach et al., 2022) and knee (Błach et al., 2021) are the most common factors related to judo injuries. Therefore the injury of anterior cruciate ligament (ACL) should be considered with interest. The All Japan Judo Federation (AJJF) has paid serious attention to the safety of judo and established a safety protocol to prevent head injury and sport-related concussion. In addition, the AJJF prohibited the use of *shime-waza* in the competitions of junior high schools (i.e. age from 12 to 15) from 2022, in order to potentially avoid unnecessary damage to the brain from unconsciousness by *shime-waza* in juvenile athletes during periods of skeletal growth and immature periods. However, the incidence and evidence of judo-related serious injuries are not fully investigated or reported throughout Japan. The purpose of this study was to investigate three serious conditions: ACL injury, head injury and neck injury (i.e. unconsciousness by *shime-waza*) in Japanese collegiate judo populations and provide useful information as a milestone to improve the environment of *judoka*. In addition, gender difference was investigated here because some studies explored sex differences in sports injuries, including ACL injury and head injury (i.e. concussion), which is not fully differentiated in *judoka*.

METHODS

This study was approved by a local IRB committee. Questionnaires were originally made with 62 items and performed on paper in March 2019, prior to the COVID-19 pandemic. No personal information to identify *judoka* was collected. In total, 518 collegiate *judoka* (286 male and 232 female) who attended a collegiate judo training camp from more than 25 independent universities nationwide in Japan, were involved in this study. Data was analysed by Pearson's Chi-squared test or Fisher's exact test for unpaired athlete groups (i.e. male vs. female) and the

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McNemar test for paired dichotomous groups (i.e. head injury vs. unconsciousness by *shime-waza*) using SPSS (ver. 29). The judo grade (*dan*) by number was compared between two groups by the Mann-Whitney U test. Values were expressed by mean average ± standard deviation. P-values under 0.05 were considered to be significant.

RESULTS

Background data

Average age of participants, judo grade and the judo experience at the time of completing the questionnaires were shown by gender in Figure 1-3. The average age (19.7 ± 1.1, male 19.8 ± 1.0, female 19.6 ± 1.1) and the judo experience (12.5 ± 2.8, male 12.7 ± 2.7, female 12.4 ± 3.0) are similar between male and female. The second grade was majority in male (72.6%) and female (71.9%). When no grade was scored as 0, the first grade as 1.0, the second grade as 2.0, the third grade as 3.0 and the fourth grade as 4.0, the average judo grade was 2.00 ± 0.52.

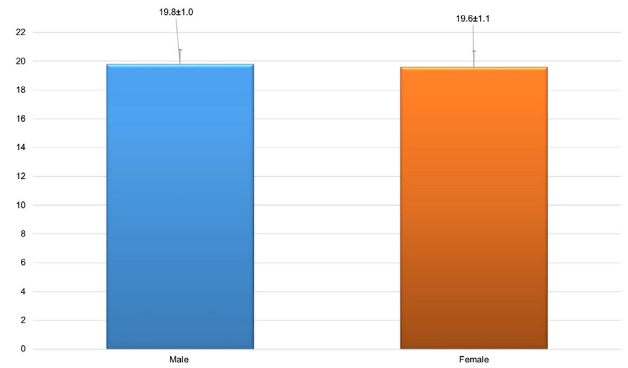

Figure 1. The average age of participants (n=518, male: n=286, female: n=232)

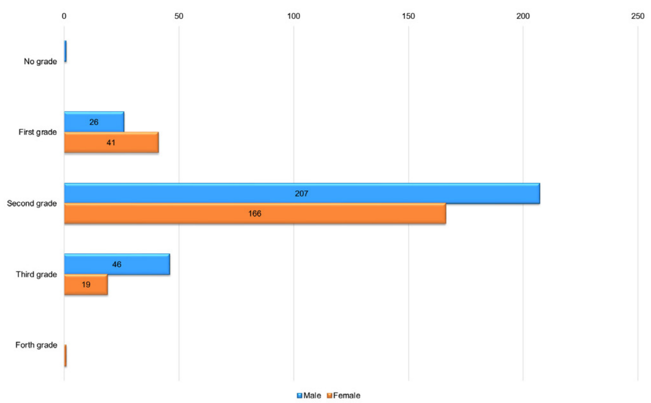

Figure 2. The judo grade (n=507)

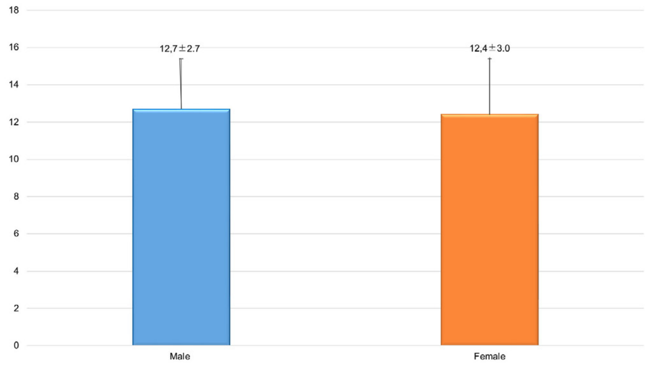

Figure 3. Years of judo experience (n=518, Male: n=286, Female: n=232)

ACL Injury

Experience in the ACL injury was seen in 70 of 518 athletes (13.7%), in which female (41 cases, 17.7%) had significantly higher numbers than male (29 cases, 10.2%, p=0.019). Out of 70 athletes with ACL injuries, 31 (44.3%) were in the right knee, 26 (37.1%) were in the left knee and 13 (18.6%) were in both knees.

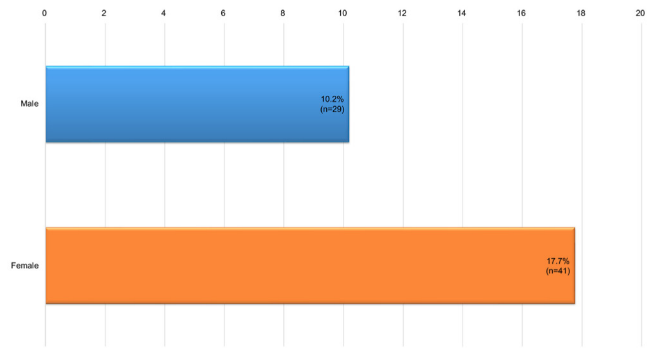

Figure 4. The incidence of ACL injury in judo athletes (n=518)

If each athlete experienced the ACL injury more than twice, the first case was focused on. Distribution of the ACL reconstruction injury by age was shown in Figure 5. The average age was similar between male (17.3 ± 2.2) and female (17.5 ± 1.9) *judoka*, however, it is noted that the first years of Japanese high school is at age 16 and college at age 19 were the first and second peaks of ACL injuries for female athletes.

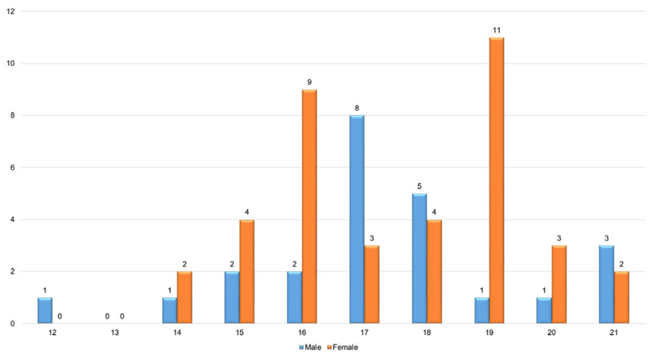

Figure 5. The number of athletes who had ACL injuries by age (n=62)

Out of 68 athletes with ACL injuries, 49 (72.1%) received surgical treatment (male 21/27 = 77.8%, female 28/41 = 68.2%), as shown in Figure 6.

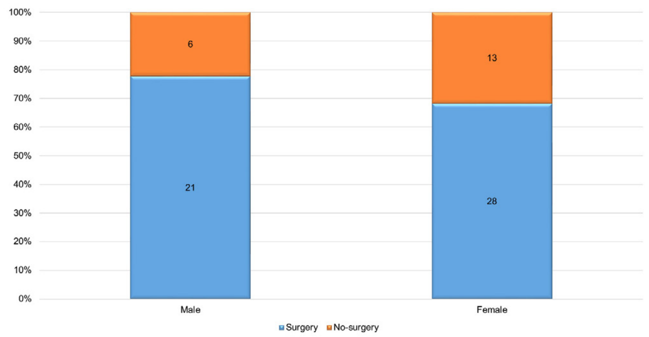

Figure 6. The incidence of a surgical reconstruction after ACL injury (n=68)

In the 43 athletes who received ACL reconstruction surgeries, all athletes (100%) returned to practice within a year and 36 athletes (83.7%) returned to a competition level within one year (i.e. 3 athletes took time over 1 year, 4 athletes did not return yet). In the 39 athletes who returned to competition, 46.2% of them recognised that their performances at the time of the questionnaire were almost equal to their pre-injury levels (male 5/18 = 27.8%, female 13/21 = 61.9%), as shown in Figure 7. Of note, 10 of 39 athletes (25.6%) subsequently injured their contralateral ACL as the second incident.

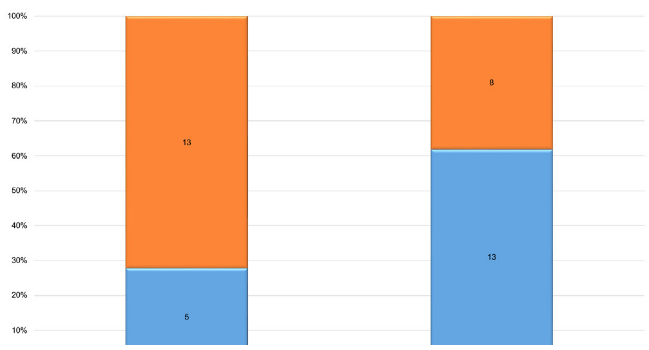

Figure 7. The performance level after the ACL surgical reconstruction (n=40)

In athletes who recognised that their performances were lower than their pre-injury levels, a variety of physical concerns were self-reported, including reductions in leg muscle power, core stability, knee range of motion, performance speed and jumping, as shown in Figure 8. After the first ACL reconstruction, the re-rupture of the same ACL occurred in 22.7% (male 26.3%, female 20.8%).

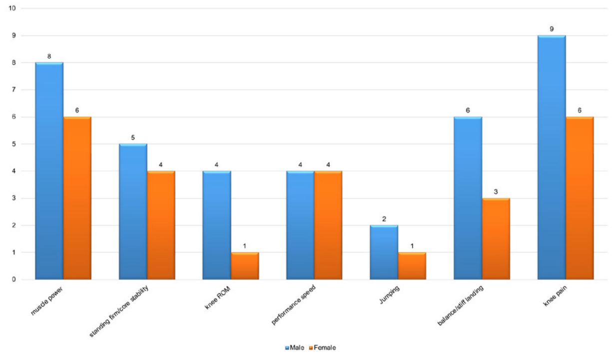

Figure 8. The self-reported functional reductions after the ACL reconstruction surgery (n=63)

Head Injury

Experience of head injuries was seen in 148 athletes (31.2%) with similar incidence between male (32.2%) and female (29.8%), as shown in Figure 9. If each athlete experienced head injuries more than twice, the worst case was focused on afterwards. The detail of head injuries from 130 athletes was presented in Figure 10 and concussion was the most frequent (83.1%) with similar incidence by gender (male 79.2%, female 88.7%), followed by head banging. There was one case of hematoma on the brain surface (sub-DH: subdural hematoma, extra-DH: extradural hematoma).

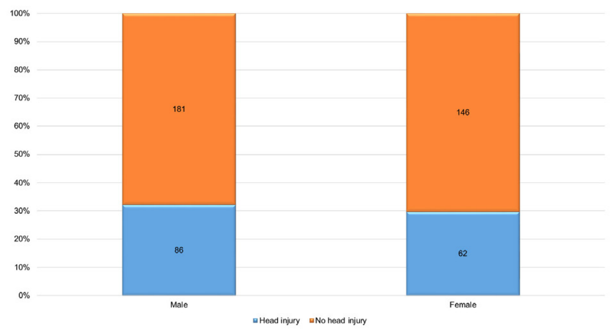

Figure 9. The incidence of head injury (n=475)

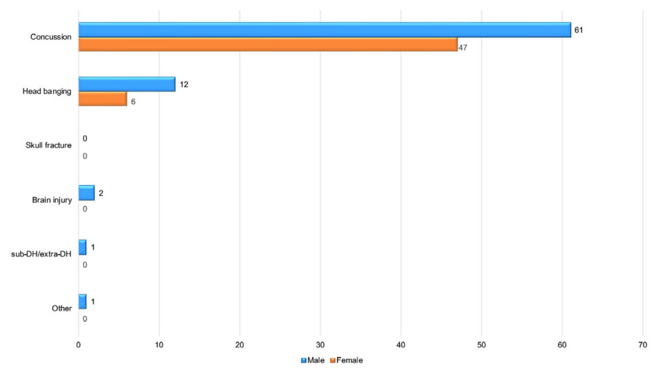

Figure 10. The list of head injuries (n=130)

Age at the time of head injury was shown in Figure 11, in which the average age was similar between male (16.3 ± 3.1) and female (16.2 ± 3.1) *judoka*.

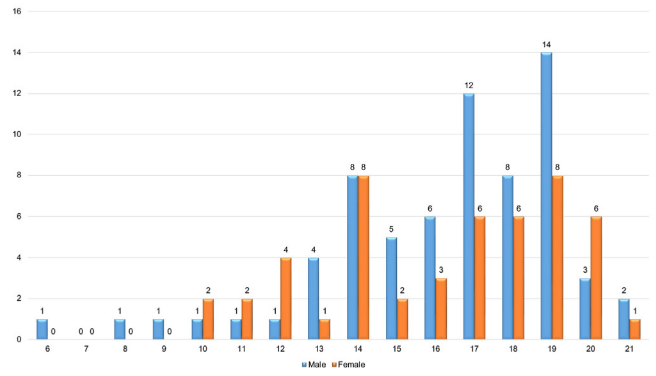

Figure 11. The number of athletes who had head injuries by age (n=117)

The judo grade (*dan*) at the time of head injury was shown in Figure 12. When no grade was scored as 0, the first grade as 1.0, the second grade as 2.0, and the third grade as 3.0 for athletes with head injury, the average grade at the time of head injury (1.24 ± 0.71) was significantly lower than that of the current grade (2.04 ± 0.51, p<0.001).

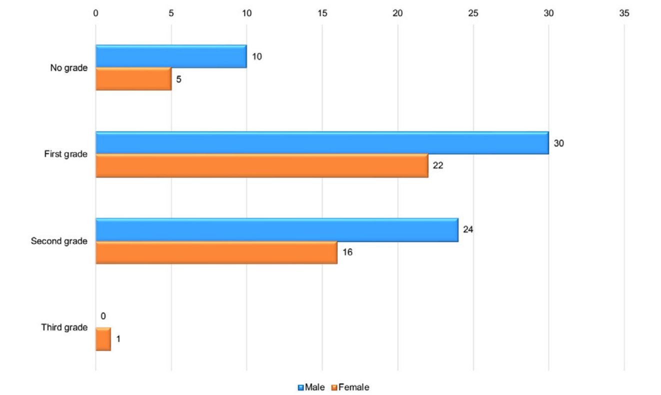

Figure 12. The judo grade at the time of head injury (n=108)

The list of *waza* leading to head injuries was shown in Figure 13. O-soto-gari (35.6%) and seoi-nage (21.9%), followed by *kaeshi-waza* (13.7%) were *tori*'s major techniques when *uke* received head injuries.

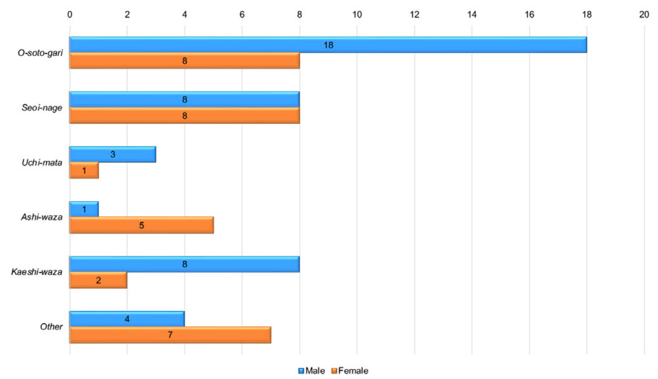

Figure 13. The list of *waza* leading to the incident of head injury (n=73)

After head injury, 48.1% of athletes (male 47.3%, female 49.1%) were referred to a doctor, as shown in Figure 14.

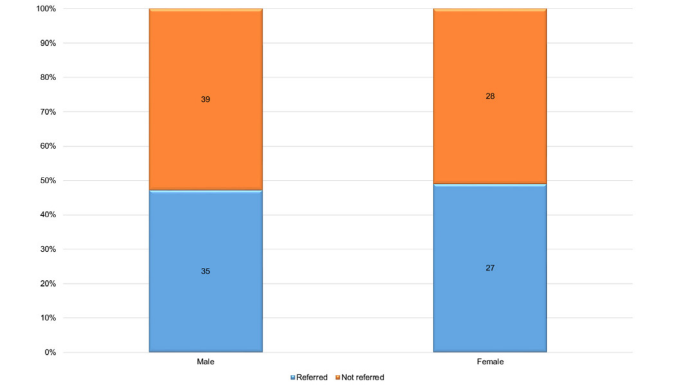

Figure 14. The number of athletes who were referred to a doctor after an incident of head injury (n=129)

After head injuries, 45.2% of athletes (male 39.7%, female 52.8%) returned to judo practice within the next day, as shown in Figure 15.

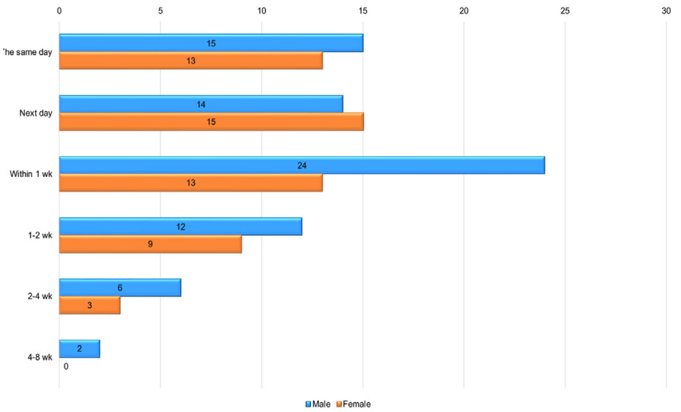

Figure 15. Time before going back to judo practice after head injury (n=126)

Unconsciousness by *Shime-Waza*

Experience of experienceing unconsciousness by *shime-waza* was seen in 286 athletes (59.1%) with similar incidence between male (62.6%) and female (54.8%) *judoka*, as shown in Figure 16. Experience in providing opponent with unconsciousness by *shime-waza* was seen in 197 athletes (57.4%) with similar incidence between male (58.9%) and female (55.6%), as shown in Figure 17. If each athlete experienced unconsciousness by *shime-waza* more than twice, the worst case of unconsciousness was focused on afterwards.

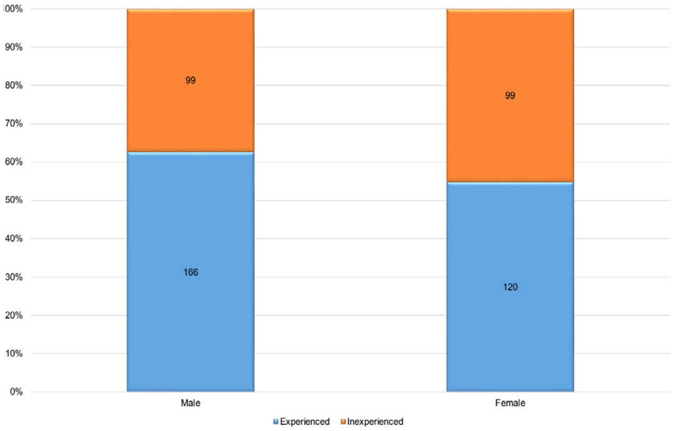

Figure 16. Experience in receiving unconsciousness by *shime-waza* from opponent (n=484)

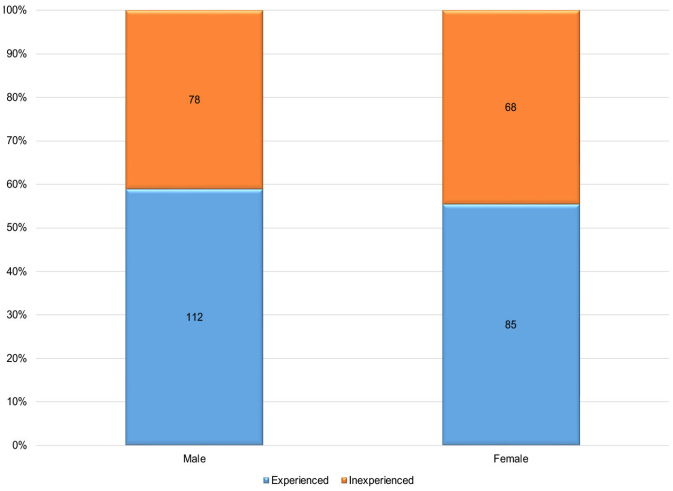

Figure 17. Experience in providing opponent with unconsciousness by *shime-waza* (n=343)

Age at the time of experiencing unconsciousness by *shime-waza* was shown in Figure 18, in which the average age (14.8 ± 2.4) was similar between male (14.8 ± 2.3) and female (14.9 ± 2.5 ± 3.1).

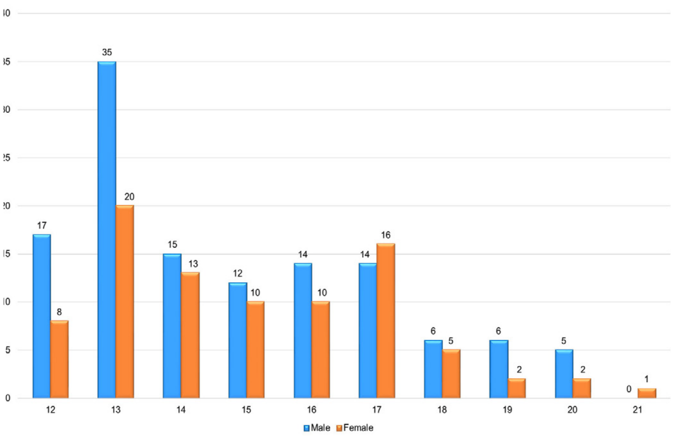

Figure 18. Cases of experiencing unconsciousness by *shime-waza* by age (n=211)

The judo grade (*dan*) at the time of experiencing unconsciousness by *shime-waza* was shown in Figure 19. When no grade was scored as 0, the first grade as 1.0, the second grade as 2.0, and the third grade as 3.0 for athletes with receiving unconsciousness by *shime-waza*, the average grade at the time of receiving unconsciousness by *shime-waza* (0.88 ± 0.60) was significantly lower than that of the current grade (2.02 ± 0.53, p<0.001).

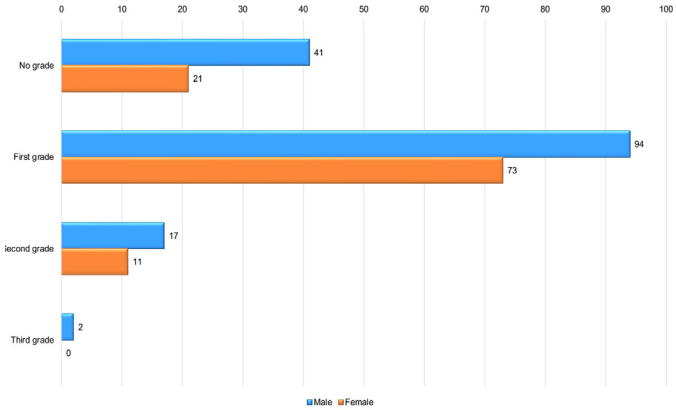

Figure 19. The judo grade at the time of experiencing unconsciousness by *shime-waza* (n=259)

In athletes experiencing unconsciousness by *shime-waza*, 71.3% reported the incidents to responsive coaches at the time of unconsciousness by *shime-waza* with significant difference by gender (male 59.1%, female 88.1%, p<0.001), as shown in Figure 20. After experiencing unconsciousness by *shime-waza*, 97.8% of athletes (male 99.4%, female 95.6%) returned to judo practice within the next day, as shown in Figure 21.

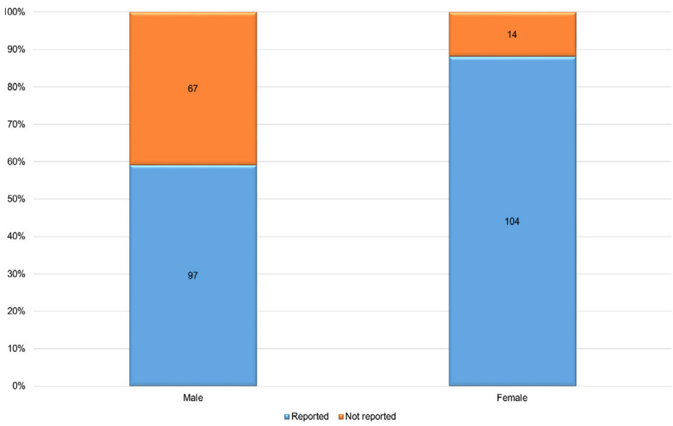

Figure 20. The number of athletes who reported to responsive coaches after an incident of unconsciousness by *shime-waza* (n=282)

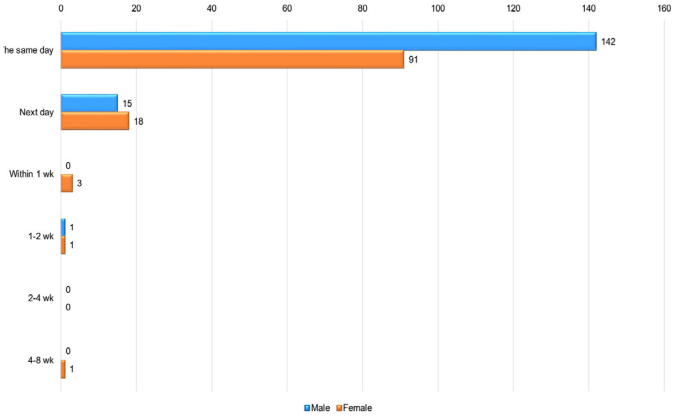

Figure 21. Time before going back to judo practice after an incident of unconsciousness by *shime-waza* (n=272)

After providing an opponent with unconsciousness by *shime-waza*, 34.8% of athletes contributed to the recovery of the opponent, with a significant difference by gender (male 57.7%, female 11.4%, p<0.001), as shown in Figure 22. Consequently, how the opponent was cared for towards recovery was shown in Figure 23. Medical symptoms after experiencing unconsciousness by *shime-waza* was shown in Figure 24.

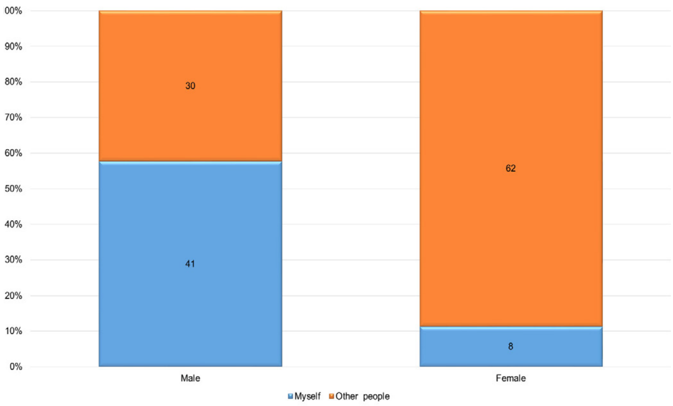

Figure 22. The number of athletes who took care of the opponent by themselves or other people after the incident of providing unconsciousness by *shime-waza* (n=141)

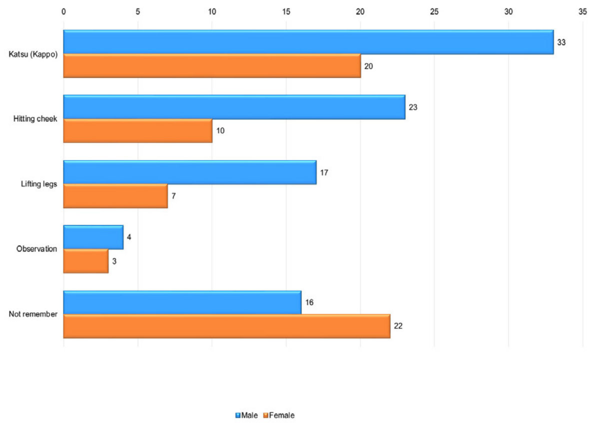

Figure 23. The way of taking care of the unconsciousness by *shime-waza* (n=155)

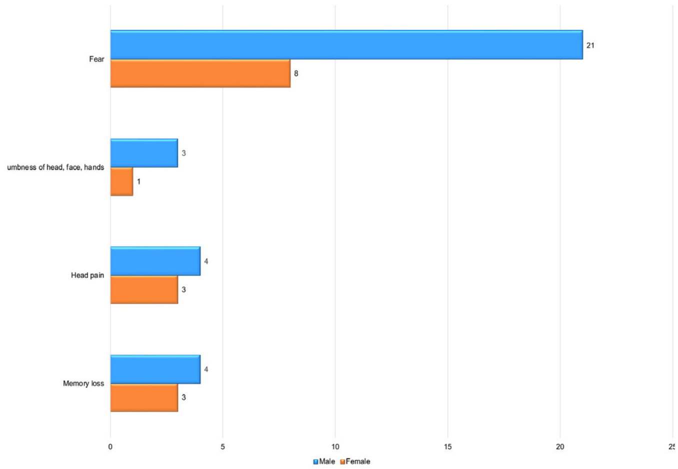

Figure 24. Symptoms after the recovery from unconsciousness by *shime-waza*

When the relationship between unconsciousness by *shime-waza* and head injury was investigated, interestingly there was a significant correlation (McNemar test, p<0.001), as shown in Table 1. In addition, in the *judoka* (n=99) who had experience both in unconsciousness by *shime-waza* and head injury, the judo grade (*dan*) at the time of unconsciousness by *shime-waza* was significantly lower (0.91 ± 0.59) than that of head injury (1.19 ± 0.62, Mann-Whitney U test, p=0.03).

Table 1. Chi-square test results for experiences of unconsciousness by *shime-waza* and head injury

		Unconsciousness by *shime-waza*				Pearson's Chi-square test
		No	Yes	Total	X^2	p
Head injury	No	147	186	333	6.02	0.014
	Yes	47	99	146		
	Total	194	285	479		

a: Fisher's test, b: McNemar test

DISCUSSION

In this study, we investigated the incidence and its related factors of ACL injury, head injury and neck injury (i.e. unconsciousness by *shime-waza*) in the Japanese collegiate population and expressed the data by differentiating re gender differences.

ACL Injury

ACL injury is a common and debilitating injury among athletes. It can occur from both contact and non-contact mechanisms (Hootman, et al., 2007; Arendt & Dick, 1995). The average incidence of ACL rupture was approximately

1 in 3500 across athlete populations (Daniel, et al., 1994) and most ACL injuries to women occurred through a non-contact mechanism (60%) versus a contact mechanism for men (59%) (Agel et al., 2016). In the current study, 52 of 70 cases (74.3%) were proven as a contact mechanism (*tori* 17 cases, *uke* 35 cases, unknown 18 cases, data not shown), in which 12 of 18 cases (66.7%) in male and 23 of 34 cases (67.6%) in female *judoka* occurred through contact mechanisms. We found the incidence of ACL injury was significantly higher in women (17.7%) than in men (10.2%) in Figure 4, consistent with the evidence that women have a higher incidence rate of ACL injury (Montalvo et al., 2019). In the current study, male athletes received ACL surgery more than female athletes (male 77.8%, female 68.2%, Figure 6), consistent with the previous report that males were more likely to undergo ACL reconstruction than females, following ACL injury diagnosis (Collins et al, 2013). The judo grade (*dan*) at the point of incident of ACL injury was significantly lower (1.38 ± 0.67) than that of the current grade (2.00 ± 0.52, data not shown) and the post-operative performance in competition was satisfactory in a limited population (male 27.8%, female 61.9%, Figure 7). Therefore, it is likely that athletes who received ACL reconstruction surgery continued to suffer from a loss of physical function in the knee. In fact, several physical factors (i.e. leg muscle power, standing firm/core stability, knee range of motion, performance speed, balance/stiff landing, etc. Figure 8) appeared to be functionally reduced. It is known that after ACL reconstruction surgery, the level of competitive sport can be reduced both in male and female athletes when compared with the level prior to the incident of ACL injury (Brophy et al., 2012). The incidence of the ACL re-rupture following ACL reconstruction surgery in the current study (22.7%) was consistent with previous studies (Paterno, 2015). Recent systematic reviews, however, showed the risk of ipsilateral retears at 5.8% and contralateral injuries at 11.8% (Sepúlveda et al., 2017). The contralateral injury was seen in the 25.6% of athletes who received ACL reconstruction surgery. Of note, 77.8% of athletes who received ACL reconstruction surgery have the fear of ACL re-rupture on the ipsilateral same knee (male 70%, female 83%, data not shown). Most of the judo athletes returned to practice and competition within a year in the current study, which is consistent with other sports. Because some considerations after ACL reconstruction surgery were revealed from this study, including reduced physical activities, the fear of re-rupture and relatively higher rates of contralateral ACL injury and ipsilateral re-rupture, it is desired to establish a judo-specific protocol to return to practice and competition, spearately from other sports. This should include the surgical technique of ACL reconstruction, the menu of post-operative rehabilitation and the proper timing to return to practice and competition. The current protocol to return competition within a year would be too short for competitive *judoka*.

Head Injury

A concussion is a form of traumatic brain injury and is the most common head injury in contact sports. In this study, a third of collegiate *judoka* had experience of head injures (31.2%, Figure 9) and most of them were concussion (83.1%, Figure 10), in which no significant difference was determined between male (79.2) and female (88.7%) athletes. This result is interesting because female athletes have a higher risk of sport-related concussion compared to male athletes in some sports (i.e. soccer, basketball, softball/baseball) (Zuckerman et al, 2015; Chandran et al, 2021) partly because females tend to have a reduced amount of neck girth and strength (Tierney et al., 2005). It is likely that, for female *judoka*, the neck is strengthened and thus the incidence of concussion is not higher than for men. The *uke*'s judo grade (*dan*) at the time of head injury was significantly lower (1.24 ± 0.71) than that of the current grade (2.04 ± 0.51, Figure 11) and o-soto-gari, seoi-nage and *kaeshi-waza* were *tori*'s major techniques when *uke* received head injuries (Figure 12). In the current study, the head was injured mostly on the back (Back 74.2%, Front 10.5%, Sides 12.1%, Eye/Nose/Ear 3.2%, data not shown). In athletes who received head injuries, half of them derecognised that their head injuries were unpredictable and impossible to avoid (data not shown). Therefore, it is critically important for *tori*, who uses those techniques above, to avoid unnecessary damage to *uke*'s head and for *uke* to improve their predictions as well as *ukemi* techniques. In addition, about a half of the athletes who had head injuries were not referred to a doctor (48.1%, Figure 14) and returned to judo practice within the next day (45.2%, Figure 15). Therefore, for the improvement of *judoka* environments, it is critically important to educate not only athletes but also coaches, to reduce the incidence of head injury and encourage proper actions following incidents of head injury. For this purpose, the AJJF issued a safety protocol for *judoka* in 2011 and 2015 to prevent head injuries and sport-related concussion. The number of serious cases of head injury in Japan has been reduced since the protocol was issued.

Unconsciousness by *Shime-Waza*

Unconsciousness following *shime-waza* is unique to judo and is not fully investigated regarding incidence and its related factors. The incidence of experiencing unconsciousness by *shime-waza* from an opponent was about 60% (Figure 16), similar to the incidence of providing it to an opponent (Figure 17). These values were slightly lower than in the previous report (Matsunaga et al., 2021) in which the incidence of unconsciousness by *shime-waza* was below 70% for *judoka* in their twenties, while its sample size was quite small (i.e. less than 10 people). The average age of receiving the worst, unforgettable unconsciousness by *shime-waza* was 14.8 ± 2.3, with a peak of age 13 which is the first year of Japanese junior high school. Thus, it is understandable that the AJJF prohibited the use of *shime-waza* in junior high school competitions from age 12 to 15 in Japan. Moreover, the average judo grade at incidents of unconsciousness was 0.88 ± 0.60, indicating that the time of receiving the worst unconsciousness could be prior to becoming a black belt. The incidence reporting to responsive coaches at the time of unconsciousness by *shime-waza* was significantly lower in male athletes (59.1%) compared to female athletes (88.1%), probably because the presence of responsive coaches at incidents of unconsciousness was lower in male athletes (88.6%) when compared with female athletes (97.5%, data not shown). After experiencing unconsciousness by *shime-waza*, 97.8% of athletes (male 99.4%, female 95.6%) returned to judo practice within the next day. This instant return to judo practice would be a critical concern because one in seven (14%) post-unconsciousness *judoka* at junior high school age displayed a variety of symptoms after the recovery from the unconsciousness by *shime-waza* (Ikumi et al, 2021) including wandering, numbness of the limbs, dizziness and nausea that are also seen as symptoms of concussion. Of note, while those symptoms usually disappeared within 5 minutes after the onset of unconsciousness in most *judoka*, one case lasted more than one hour and another lasted more than 24 hours (Ikumi et al, 2021). In the current study, several symptoms were self-reported after waking from the unconsciousness following *shime-waza*, including the numbness of head, face and hands, headache, and poor memory (Figure 24). It is interesting that 29 of 287 *judoka* (10.1%) kept recognising the fear of unconsciousness after the worst incident of the unconsciousness by *shime-waza* up to the time of the questionnaire. Since the average age at the time of the worst unconsciousness was 14.8 and the average age at the time of questionnaire was 19.7, it is possible that the fear of unconsciousness from *shime-waza* at the juvenile age (i.e. junior high school) can last at least 5 years, up to the time of college. One report concluded no acute or long-term effects of unconsciousness by *shime-waza* on physical activity (Matsunaga et al, 2021), however, teen *judoka* were not included in the study and the fear of unconsciousness was not investigated. Further study would be desired to reveal the long-term effects of unconsciousness from *shime-waza* that happened at teen age on physical and mental aspects. From the point of safety, it is important for *judoka* to learn more about how to recover the opponent from unconsciousness because only 34.8% of athletes (male 57.7%, female 11.4%, Figure 22), by themselves, contributed to the recovery of an opponent from unconsciousness. In the current study, there was a significant correlation between two events of unconsciousness by *shime-waza* and head injury. Because the judo grade was significantly lower at the time of unconsciousness from *shime-waza* compared to the time of head injury, it is possible that the initial incident of unconsciousness could affect the second incident of head injury for some reason. As mentioned before, potential symptoms from the serious, unforgettable unconsciousness and the timing of head injury should be precisely investigated as an extension study in the future. In particular, it is hypothesised that the incidence of head injury could increase in juvenile *judoka* who have recently experienced unconsciousness by *shime-waza*. A substantial sample size would be necessary to reveal the cause and consequence of the relationship between the two events.

Limitations of This Study

There are some limitations to this study. Firstly, while data was expressed by gender, the weight class was not investigated, primarily due to a limited sample size. Secondly, the incidence of injuries was not normalised by the exposure time to judo for each person. Thirdly, specific questions to reveal the relationship between unconsciousness and head injury were not set up. Lastly, a follow-up survey was planned but not conducted due to the COVID-19 pandemic.

CONCLUSION

This study focused on collegiate judo athletes and revealed the incidence and related factors of three serious injuries. We found that there are considerations for *judoka* who received ACL reconstruction surgery. Concussion is the most frequent head injury and 60% of *judoka* had experience in receiving and or providing unconsciousness by *shime-waza*. In order to reduce the incident rates of head injury and unconsciousness by *shime-waza*, there is a need to establish a safety protocol that improves judo techniques and environments.

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The Effectiveness of Tactical Actions on the Offensive System of Male Elite Judo Athletes in Olympic Tournaments

By Amar Ait Ali Yahia

Abstract: *A judo fight is an intellectual space because of the tactics involved in its management. As a fundamental factor, these tactics contribute effectively to performance. This study aimed to calculate, compare and analyse the most frequent and effective tactical actions chosen by male elite athletes. A sample of 112 Olympic medallists, comprising 28 gold, 28 silver and 56 bronze medals, accomplished 3,991 tactical actions in 575 fights at four successive Olympic Games (2004-2016). The Kolmogorov-Smirnov test assessed the normality of the collected data. The Levene's test showed the equality of variance. ANOVA (one factor) made inter-Olympic (longitudinal study) and intra-Olympic (cross-sectional study) comparisons, followed by the Post hoc Bonferroni test ($p< 0.05$). Eta squared $\eta 2$ and d of Cohen estimated the effect size. Olympic medallists performed respectively 74.8±6.9% direct attacks, 9.3±3.8% combination, 7.8±3.3% standing to ground transition, and 5.6±3.4% counterattack. In terms of effectiveness, direct attack 54.1±13.3% dominates ahead of counterattack 15.3±10.1%, combination 14.6±7.5%, and standing to ground transition 13.6±8.9%. Feint and repeated attacks had a negligible contribution. The offensive system of Olympic medallists is mostly based on direct attacks, but additional options such as counterattack, combination and standing to ground transition also led to their success. The findings of this study could help improve the tactical preparation of elite judo athletes.*

Keywords: *combats sports; judoka; tactics analysis; high-level; competition*

Judo performance is complex, unpredictable and multifactorial. A literature review highlights many theoretical models based on individual and environmental factors that assist coaches in planning their *judoka*'s success (Maekawa et al., 2013; Ferreira Celestino et al., 2015; Uriarte Marcos et al., 2019; Mazzei et al., 2020; Brito et al., 2020). These models consider tactics as one of the principal factors contributing effectively to judo achievement. From a general perspective, tactics are the art of fixing means to achieve immediate or short-term objectives (Black & Black, 2006). Concerning judo, tactics are the art and science of fighting, involving variables such as grips, displacements, defence, velocity, and executing technical movements (Sacripanti, 2015). Tactics are also intellectual tools to conduct bouts, allowing a rational technical choice by considering both the opponent and external conditions. They are various offensive and defensive plans that overcome an opponent while following the refereeing rules. Lee (1994) identified a tactical plan as a reflection elaborated by the coach for his elite athlete, considering distinct hypotheses to enable him to participate assuredly and securely in a competition by imagining its progress. Managing a tournament, leading a fight and making up an attack are the primary objectives of tactical preparation (Plotnikov, 2010). In addition, judo competition requires different tactics. The elite athlete adopts energy tactics to impose their physical approach when choosing various intensities of confrontation. they use psychological tactics to neutralise, frustrate and prevent the opponent from expressing himself offensively while disturbing his means, serenity and attention. To counterbalance the opponent's technical project, the elite athlete chooses the technical tactics by considering his displacements, *kumi-kata*, the direction of unbalance, and body position (Rosso et al., 2006).

Judo competition is an uncertain environment demanding a specific tactical mastery to execute technical action. Opponents strengthen their defence to avoid being thrown or immobilised, making victory challenging. For this reason, competition management requires a developed tactical sense, an attribute of outstanding elite athletes. Tactical knowledge creates favourable conditions to express *tokui-waza* (preferred technique). Despite some weaknesses, elite athletes exploit every opportunity to impose their strengths, leading to exceptional performances. Indeed, tactical versatility contributed to Waldemar Legien's 1988 and 1992 Olympic titles (Boguszewski, 2006; Adam et al., 2014). Effective attacks and strong defence allowed Teddy Riner to win 2012 and 2016 gold medals

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(Adam & Volska, 2016). Considering his exploits, experts cite Tadahiro Nomura as the greatest *judoka*. His tactical mastery enabled him to win three Olympic gold medals in a row (Atlanta 1996, Sydney 2000, and Athens 2004), becoming the only *judoka* to achieve such a performance in judo history (Olympics.com, 2021). Despite his distinguished achievements, the scientific community continues to ignore this living legend as a research subject. His longevity is exceptional since he retired 19 years after his first Olympic title, at age 40 (Rouquette, 2015).

To succeed in sport, the elite athlete must adapt their tactical choices to their opponent, rationally distribute their efforts and conceal their technical and tactical intentions (Manno, 1992). Tactical thinking is expressed through tactical knowledge, experience and the ability to make rapid and effective decisions (Kriventsova et al., 2017). To improve it, Zadorozhna et al. (2020) recommend some tasks such as adopting an effective strategy, building up the most effective tactical options, training how to make the right decision during the fight and learning how to anticipate the opponent's actions. In contrast, tactical knowledge may allow athletes to understand tactics, acquire a repertoire of tactical patterns and apply them based on different situations and opponents (Zadorozhna et al., 2021). Further, tactical versatility is the ability to master various tactical actions for solving defensive problems and be tactically unpredictable. A long-term tactical syllabus is required to develop it. As tactical learning topics, the French Judo Federation has proposed direct attack, combination, feint, repeated attack, counterattack, and ground to standing transition (FJFAD, 1989).

Physical, technical and psychological aspects are determinant factors in sports performance. However, most judo researchers have focused on these factors, underestimating the contribution of tactics. Analysing judo's success from a tactical standpoint could challenge this opinion and address several unanswered practical issues. Also, this study could investigate how elite judo athletes configure their tactical options in defence and attack. A rigorous examination of the principal tactical trends contributes to the rational development of judo training. Several authors analysing the Olympic Games and world championships have failed to study tactics variables profoundly (Moya & Tartbull, 2003; Heinisch & Busch, 2011; Heinisch et al., 2013; Ito et al., 2014; Ait Ali Yahia, 2014, 2015; Boguszewski, 2016; Mayo et al., 2019; Nagai et al., 2019). Hence, modelling elite judo tendencies is possible by evaluating several Olympic Games. This study aims to calculate, compare and analyse the most frequent and effective tactical actions implemented by Olympic male medallists. Thus, considering the judo refereeing changes in recent years (IJF, 2010, 2013), we hypothesised that a tactical tendency specific to each Olympic Games emerged through the offensive approach of Olympic medallists.

METHODS AND MATERIAL

Participants

The present research analysed 112 male medallists comprising 28 gold, 28 silver and 56 bronze medals in all seven weight categories from the 2004 to 2016 Olympic tournaments. The video recordings of 575 fights (138 gold, 141 silver, and 296 bronze) formed the research material. To throw their opponents, medallists performed 3,991 tactical actions: 956 gold, 1060 silver, and 1975 bronze (Table 1). The analysis investigated eliminatory fights, quarter-finals, semi-finals, finals, repechage and third place.

Measures

The current research analysed tactical actions defined by the French Judo Federation and Associated Disciplines (FJFAD, 1989). Tactical knowledge of judo includes several ways to beat the opponent. A direct attack is any attempt to throw the opponent with a single attack. When this first attack fails because the defender blocks it, *Tori* (the attacker) can attempt a second attack; this is a combination. Faced with strict defence, the attacker can try to

Table 1. Data of Olympic medallists

	Medallists			Fights			Tactical actions		
	Gold	Silver	Bronze	Gold	Silver	Bronze	Gold	Silver	Bronze
Athens	7	7	14	35	35	81	239	276	558
Beijing	7	7	14	34	35	74	232	319	542
London	7	7	14	35	36	71	239	240	510
Rio	7	7	14	34	35	70	246	225	365

feint, simulating an action in one direction to trick the opponent into performing the first planned technique. If the throw is ineffective and the opponent releases his guard, the attacker may repeat the same action several times, adapting to the opponent's new positions. It is called a repeat attack. Standing to ground transition marks the passage of the fight from standing (*tachi-waza*) to ground work (*ne-waza*) positions. Finally, the counterattack is the ability to perform a technique from an action initiated by the opponent.

Data collection

An Excel spreadsheet was necessary to collect data from official videos of medallists' Olympic judo fights. Data collection was made possible thanks to the International Olympic Committee's Multimedia Library (http://extranet.olympic.org). Our doctoral dissertation studied the offensive activity of the medallists at the 2004-2012 Olympic Games (Ait Ali Yahia, 2015). Two years later we examined the fights from Rio de Janeiro 2016. Previous research rechecked this data (Ait Ali Yahia, 2019, 2020, 2021).

Ethics

When consent is impractical or difficult to get and the advantages of the proposed study outweigh the disadvantages, researchers could proceed without authorization (Porsdam Mann et al., 2016). Sensitive data that third parties could misuse were not collected. We guaranteed the confidentiality and anonymity of these participants. There are no ethical issues in studying primary data collected from sports events, generated by a structured observation.

Sample Variables

The variables of this study are technical action, technical group (*nage-waza*, *ne-waza*), score and tactical action. An attempted attack is an action that respects *kuzushi* (breaking the balance), *tsukuri* (positioning the body) and *kake* (throwing phase) without scoring. In contrast, an effective attack is an action the referee awards a score for. Also, the present research assessed the frequencies and effectiveness of all tactical actions in percentage values (%). A tactical action is effective when it is associated with an attack rewarded by the referee. The study compared these tactical actions in an inter-Olympic analysis (longitudinal) and intra-Olympic analysis (cross-sectional).

Statistical Analysis

The Kolmogorov-Smirnov test assessed the normality of the collected data, while the Levene's test showed the equality of variance. Descriptive data is presented as the maximum, minimum, median (first quartile, third quartile), mean, and standard deviation with 95% of confidence intervals (95% CI). One-way analysis of variance conducted inter-Olympic (longitudinal study) and intra-Olympic (cross-sectional study) comparisons, followed by the Bonferroni test. Eta squared η^2 calculated the effect size (small= 0.009, medium= 0.058, and large= 0.137) (Cohen, 1988). Cohen's d determined the effect size for Student's t-test. Challenging Cohen's approach, Hopkins (2002) proposed a Likert scale of sizes: trivial: 0.0-0.2, small: 0.2-0.6, medium: 0.6-1.2, large: 1.2-2.0, very large: 2.0-4.0, and nearly perfect: >4.0. Data was analysed using IBM SPSS predictive analytics software (version 27.0.1.0, SPSS, Inc., Chicago, IL, USA). The significance level was set at 5%.

RESULTS

Frequencies of Tactical Actions by Olympic Cycle

Tactical actions frequencies (%) of medallists are presented in Table 2. There was an effect of tactical actions chosen by medallists in Athens ($F_{2.270}$ = 356.240, p = 0.000, η^2= 0.917, large), Beijing ($F_{2.270}$ = 683.682, p = 0.000, η^2 = 0.955, large), London ($F_{2.270}$ = 356.764, p = 0.000, η^2 = 0.917, large), and Rio ($F_{2.270}$ = 741.946, p = 0.000, η^2 = 0.958, large).

Concerning Athens medallists, the *post hoc* Bonferroni test identified differences between tactical actions. The direct attack presented a higher frequency compared with the combination (p = 0.000, 95% CI [54.1, 66.2], d = 5.130, nearly perfect), counterattack (p = 0.000, 95% CI [57.4, 69.5], d = 5.890, nearly perfect), standing to ground transition (p = 0.000, 95% CI [58.9, 71.0], d = 6.143, nearly perfect), feint (p = 0.000, 95% CI [64.2, 76.3], d = 6.987, nearly perfect), and repeat attack (p = 0.000, 95% CI [63.8, 75.9], d = 6.924, nearly perfect). The combination showed a higher frequency than feint (p = 0.000, 95% CI [4.1, 16.2], d = 1.586, large) and repeat attack (p = 0.000, 95% CI [3.6, 15.7], d = 1.502, large). Counterattack presented a higher frequency compared with feint (p = 0.015, 95% CI [0.8, 12.9], d = 1.533, large) and repeat attack (p = 0.032, 95% CI [0.3, 12.4], d = 1.408, large).

The *post hoc* Bonferroni test confirmed differences for Beijing medallists. The direct attack presented a higher frequency compared with the combination (p = 0.000, 95% CI [63.7, 73.2], d = 8.580, large), counterattack (p = 0.000, 95% CI [65.6, 75.0], d = 8.369, nearly perfect), standing to ground transition (p = 0.000, 95% CI [61.8, 71.2], d = 8.006, nearly perfect), feint (p = 0.000, 95% CI [70.5, 80.0], d = 10.492, nearly perfect), and repeat attack (p = 0.000, 95% CI [71.2, 80.7], d = 10.758, nearly perfect). The combination showed a higher frequency than the feint (p = 0.000, 95% CI [2.1, 11.5], d = 1.719, large) and repeat attack (p = 0.000, 95% CI [2.8, 12.3], d = 2.002, very large). Counterattack presented a higher frequency than feint (p = 0.033, 95% CI [0.2, 9.7], d = 1.037, medium) and repeat attack (p = 0.007, 95% CI [0.9, 10.4], d = 1.231, large). Standing to ground transition showed a higher frequency than feint (p = 0.000, 95% CI [4.0, 13.5], d = 1.908, large) and repeat attack (p = 0.000, 95% CI [4.7, 14.2], d = 2.146, very large).

Table 2. Frequencies (%) of tactical actions by Olympic cycle

		Direct attack	Combination	Counterattack	SGT	Feint	Repeat attack
	(Min; Max)	(20.0; 97.4)	(0.0; 36.0)	(0.0; 20.0)	(0.0; 18.8)	(0.0; 9.1)	(0.0; 8.0)
Athens	Med (Q_1; Q_3)	74.3 (66.4; 78.6)	8.5 (4.9; 17.9)	6.3 (3.1; 11.2)	5.2 (2.8; 8.7)	0.0 (0.0; 1.7)	0.0 (0.0; 2.8)
	M±SD	71.4±14.1	11.3±8.8	8.0±5.9	6.5±5.1	1.2±2.2	1.6±2.4
	(Min; Max)	(50.0; 100.0)	(0.0; 20.7)	(0.0; 29.2)	(0.0; 24.2)	(0.0; 8.1)	(0.0; 3.2)
Beijing	Med (Q_1; Q_3)	75.7 (72.7; 81.7)	7.9 (3.0; 10.1)	4.3 (0.9; 8.5)	8.1 (6.6; 12.6)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	M±SD	76.1±10.0	7.6±5.3	5.8±6.5	9.6±6.2	0.8±1.9	0.1±0.6
	(Min; Max)	(38.2; 100.0)	(0.0; 32.1)	(0.0; 23.5)	(0.0; 28.9)	(0.0; 20.0)	(0.0; 4.3)
London	Med (Q_1; Q_3)	71.8 (64.6; 81.8)	6.6 (3.2; 10.6)	2.8 (0.0; 4.6)	9.8 (5.8; 14.2)	0.0 (0.0; 2.2)	0.0 (0.0; 0.0)
	M±SD	73.7±14.0	8.4±7.6	4.4±5.6	10.6±8.0	2.2±4.9	0.6±1.3
	(Min; Max)	(57.1; 95.5)	(0.0; 22.6)	(0.0; 19.0)	(0.0; 14.3)	(0.0; 14.3)	(0.0; 6.7)
Rio	Med (Q_1; Q_3)	75.7 (69.5; 82.1)	10.3 (5.1; 13.0)	4.4 (0.0; 7.8)	5.4 (3.0; 7.8)	0.0 (0.0; 2.7)	1.2 (0.0; 3.3)
	M±SD	75.4±9.5	9.6±5.8	5.4±5.3	5.6±4.0	2.2±4.0	1.9±2.1

Min: Minimum; Max: Maximum; Med: Median; Q1: first quartile; Q3: third quartile; M: Mean; SD: Standard Deviation; Standing to Ground Transition: SGT.

ANOVA showed differences between tactical actions that occurred in London. The direct attack presented a higher frequency compared with the combination (p = 0.000, 95% CI [59.0, 71.6], d = 5.800, nearly perfect), counterattack (p = 0.000, 95% CI [63.1, 75.6], d = 6.502, nearly perfect), standing to ground transition (p = 0.000, 95% CI [56.8, 69.4], d = 5.529, nearly perfect), feint (p = 0.000, 95% CI [65.2, 77.8], d = 6.811, nearly perfect), and repeat attack (p = 0.000, 95% CI [66.8, 79.4], d = 7.341, nearly perfect). The combination showed a higher frequency than repeat attack (p = 0.005, 95% CI [1.5, 14.1], d = 1.431, large). Standing to ground transition showed a higher frequency than feint (p = 0.001, 95% CI [2.1, 14.7], d = 1.272, large) and repeat attack (p = 0.000, 95% CI [3.7, 16.3], d = 1.743, large).

The statistical analysis found differences between the tactical actions of Rio medallists. The direct attack presented a higher frequency compared with the combination (p = 0.000, 95% CI [61.3, 70.2], d = 8.337, nearly perfect), counterattack (p = 0.000, 95% CI [65.5, 74.5], d = 9.059, nearly perfect), standing to ground transition (p = 0.000, 95% CI [65.3, 74.2], d = 9.556, nearly perfect), feint (p = 0.000, 95% CI [68.7, 77.7], d = 10.027, nearly perfect), and repeat attack (p = 0.000, 95% CI [69.0, 78.0], d = 10.646, nearly perfect). The combination showed a higher frequency than feint (p = 0.000, 95% CI [3.0, 11.9], d = 1.502, large) and repeat attack (p = 0.000, 95% CI [3.3, 12.2], d = 1.777, large).

Inter-Analysis of Tactical Actions

ANOVA did not reveal differences between direct attacks ($F_{2.689}$ = 0.806, p = 0.493, η^2= 0.022, small), combinations ($F_{2.689}$ = 1.472, p = 0.226, η^2= 0.039, small), counterattacks ($F_{2.689}$ = 1.907, p = 0.133, η^2= 0.050, small), and feints ($F_{2.689}$ = 1.138, p = 0.337, η^2= 0.031, small). However, statistical analysis shows differences between standing to ground transitions ($F_{2.689}$ = 4.549, p = 0.005, η^2= 0.112, medium) and repeat attacks ($F_{2.689}$ = 6.167, p = 0.001, η^2= 0.146, large). The *post hoc* Bonferroni test confirmed differences in standing to ground transitions. London medallists showed a higher percentage than medallists of Rio (p = 0.013, 95% CI [0.7, 9.4], d = 0.799, medium). Concerning repeat attacks, the post hoc test indicated differences. Medallists of Beijing showed a shorter percentage than medallists of Athens (p = 0.010, 95% CI [0.3, 2.8], d = 0.863, medium) and Rio medallists (p = 0.002, 95% CI [0.5, 3.8], d = 1.129, medium).

Tactical Actions Effectiveness by Olympic Cycle

Table 3 shows ratios of tactical actions effectiveness. There was an effect of effectiveness tactical actions of medallists in Athens ($F_{2.270}$ = 50.684, p = 0.000, η^2= 0.610, large), Beijing ($F_{2.270}$ = 65.877, p = 0.000, η^2 = 0.670, large), London ($F_{2.270}$ = 20.720, p = 0.000, η^2 = 0.390, large), and Rio ($F_{2.270}$ = 29.168, p = 0.000, η^2 = 0.474, large).

The statistical analysis identified differences between the effectiveness of tactical actions developed in Athens. The direct attack presented higher effectiveness compared with the combination (p = 0.000, 95% CI [26.9, 50.5], d = 1.877, large), counterattack (p = 0.000, 95% CI [24.8, 48.4], d = 1.715, large), standing to ground transition (p = 0.000, 95% CI [33.2, 56.8], d = 2.187, very large), feint (p = 0.000, 95% CI [42.5, 66.1], d = 2.994, very large), and repeat attack (p = 0.000, 95% CI [41.2, 64.8], d = 2.870, very large). The combination showed a higher effectiveness than feint (p = 0.002, 95% CI [3.8, 27.4], d = 1.597, large) and repeat attack (p = 0.006, 95% CI [2.5, 26.1], d = 1.379, large). Counterattack presented a higher effectiveness compared with feint (p = 0.000, 95% CI [5.9, 29.5], d = 1.568, large) and repeat attack (p = 0.001, 95% CI [4.7, 28.3], d = 1.389, large).

Table 3. Effectiveness (%) of tactical actions by Olympic cycle

		Direct attack	Combination	Counterattack	SGT	Feint	Repeat attack
	(Min; Max)	(0.0; 100.0)	(0.0; 45.5)	(0.0; 50.0)	(0.0; 50.0)	(0.0; 8.3)	(0.0; 25.0)
Athens	Med (Q_1; Q_3)	52.8 (38.3; 67.9)	16.7 (0.0; 25.0)	15.5 (0.0; 29.8)	0.0 (0.0; 17.5)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	M±SD	54.6±25.6	15.9±13.7	18.0±15.9	9.6±13.8	0.3±1.6	1.6±5.2
	(Min; Max)	(33.3; 100.0)	(0.0; 50.0)	(0.0; 66.7)	(0.0; 42.9)	(0.0; 12.5)	(0.0; 0.0)
Beijing	Med (Q_1; Q_3)	57.1 (41.5; 75.0)	13.4 (0.0; 25.9)	0.0 (0.0; 20.0)	13.4 (0.0; 25.0)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	M±SD	59.6±21.3	14.2±14.9	12.0±18.8	13.8±14.2	0.4±2.4	0.0±0.0
	(Min; Max)	(0.0; 100.0)	(0.0; 100.0)	(0.0; 100.0)	(0.0; 75.0)	(0.0; 11.1)	(0.0; 50.0)
London	Med (Q_1; Q_3)	53.6 (38.3; 68.8)	0.0 (0.0; 20.6)	0.0 (0.0; 28.8)	0.0 (0.0; 33.3)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	M±SD	52.2±32.0	11.3±21.5	17.4±28.0	15.4±21.3	0.4±2.1	2.7±10.4
	(Min; Max)	(16.7; 100.0)	(0.0; 60.0)	(0.0; 75.0)	(0.0; 60.0)	(0.0; 25.0)	(0.0; 33.3)
Rio	Med (Q_1; Q_3)	50.0 (25.0; 66.7)	13.3 (0.0; 22.9)	0.0 (0.0; 33.3)	18.3 (0.0; 27.1)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)
	M±SD	48.1±22.1	14.1±16.5	15.9±20.7	16.5±17.4	1.5±5.6	3.8±8.9

Min: Minimum; Max: Maximum; Med: Median; Q1: first quartile; Q3: third quartile; M: Mean; SD: Standard Deviation; Standing to Ground Transition: SGT.

For Beijing medallists, the post hoc test confirmed differences. The direct attack presented higher effectiveness compared with the combination (p = 0.000, 95% CI [33.9, 56.7], d = 2.469, very large), counterattack (p = 0.000, 95% CI [36.2, 59.0], d = 2.372, very large), standing to ground transition (p = 0.000, 95% CI [34.4, 57.2], d = 2.532, very large), feint (p = 0.000, 95% CI [47.7, 70.5], d = 3.905, very large), and repeat attack (p = 0.000, 95% CI [48.1, 71.0], d = 3.959, very large). The combination showed higher effectiveness than feint (p = 0.006, 95% CI [2.4, 25.2], d = 1.297, large) and repeat attack (p = 0.004, 95% CI [2.8, 25.7], d = 1.365, large). Counterattack presented shorter effectiveness compared with feint (p = 0.046, 95% CI [0.1, 22.9], d = 0.862, medium) and repeat attack (p = 0.032, 95% CI [0.6, 23.4], d = 0.902, medium). Standing to ground transition showed higher effectiveness than feint (p = 0.010, 95% CI [1.9, 24.7], d = 1.311, large) and repeat attack (p = 0.000, 95% CI [2.4, 25.2], d = 1.373, large).

ANOVA showed differences between the effectiveness of tactical actions that occurred in London. The direct attack presented higher effectiveness compared with the combination (p = 0.000, 95% CI [23.6, 58.2], d = 1.499, large), counterattack (p = 0.000, 95% CI [17.5, 52.1], d = 1.156, medium), standing to ground transition (p = 0.000, 95% CI [19.5, 54.2], d = 1.353, large), feint (p = 0.000, 95% CI [34.5, 69.1], d = 2.281, very large), and repeat attack (p = 0.000, 95% CI [32.2, 66.8], d = 2.078, very large).

For Rio medallists, the post hoc test revealed differences between the effectiveness of tactical actions that appeared in Rio. The direct attack presented higher effectiveness compared with the combination (p = 0.000, 95% CI [21.0, 47.0], d = 1.742, large), counterattack (p = 0.000, 95% CI [19.2, 45.2], d = 1.502, large), standing to ground transition (p = 0.000, 95% CI [18.6, 44.7], d = 1.588, large), feint (p = 0.000, 95% CI [33.6, 59.7], d = 2.891, very large), and repeat attack (p = 0.000, 95% CI [31.3, 57.4], d = 2.630, very large). Feint presented shorter effectiveness compared with the counterattack (p = 0.018, 95% CI [1.4, 27.5], d = 0.951, medium) and standing to ground transition (p = 0.011, 95% CI [2.0, 28.1], d = 1.162, medium).

Inter-Analysis of Tactical Actions Effectiveness

A one-way ANOVA revealed no significant differences between direct attacks ($F_{2.689}$ = 0.971, p = 0.409, η^2= 0.026, small), combinations ($F_{2.689}$ = 0.356, p = 0.785, η^2= 0.010, small), counterattacks ($F_{2.689}$ = 0.454, p = 0.715, η^2= 0.012, small), standing to ground transitions ($F_{2.689}$ = 0.890, p = 0.449, η^2= 0.024, small), feints ($F_{2.689}$ = 0.798, p = 0.498, η^2= 0.022, small), and repeat attacks ($F_{2.689}$ = 1.364, p = 0.258, η^2= 0.037, small).

Frequencies and Effectiveness of Tactical Actions in Four Olympics Games

Table 4 shows frequencies and effectiveness of all Olympics Games. The analysis of variance highlighted a significant difference between the frequencies of tactical actions ($F_{2.270}$ = 1578.278, p = 0.000, η^2= 0.980, large) and their effectiveness ($F_{2.270}$ = 148.124, p = 0.000, η^2= 0.821, large).

Regarding frequencies, direct attack presented a higher frequency compared with the combination (p = 0.000, 95% CI [62.6, 68.5], d = 11.759, nearly perfect), counterattack (p = 0.000, 95% CI [66.3, 72.2], d = 12.722, nearly perfect), standing to ground transition (p = 0.000, 95% CI [64.1, 70.0], d = 12.388, nearly perfect), feint (p = 0.000, 95% CI [70.4, 76.3], d = 14.784, nearly perfect), and repeat attack (p = 0.000, 95% CI [70.8, 76.7], d = 14.979, nearly perfect). The combination showed a higher frequency than counterattack (p = 0.005, 95% CI [0.8, 6.7], d = 1.026, medium), feint (p = 0.000, 95% CI [4.9, 10.8], d = 2.782, very large), and repeat attack (p = 0.000, 95% CI [5.3, 11.2], d = 2.970, very large). Feint presented a shorter frequency compared with a counterattack (p = 0.001,

Table 4. Frequencies and effectiveness of tactical actions in four Olympics Games

		Direct attack	Combination	Counterattack	SGT	Feint	Repeat attack
	(Min; Max)	(53.4; 89.1)	(2.6; 17.6)	(1.1; 16.5)	(2.1; 15.5)	(0.0; 5.0)	(0.0; 3.2)
Frequencies	Med (Q_1; Q_3)	74.0 (71.3; 79.1)	9.1 (6.2; 12.0)	5.0 (3.2; 7.9)	7.3 (5.7; 9.5)	1.0 (0.6; 2.0)	0.8 (0.5; 1.8)
	M±SD	74.8±6.9	9.3±3.8	5.6±3.4	7.8±3.3	1.4±1.3	1.1±0.9
	(Min; Max)	(30.4; 84.0)	(4.0; 39.1)	(0.0; 35.0)	(3.3; 40.0)	(0.0; 8.3)	(0.0; 8.3)
Effectiveness	Med (Q_1; Q_3)	53.4 (47.4; 63.5)	12.8 (10.0; 19.3)	14.6 (6.2; 23.8)	12.0 (6.3; 19.3)	0.0 (0.0; 0.0)	0.0 (0.0; 3.8)
	M±SD	54.1±13.3	14.6±7.5	15.3±10.1	13.6±8.9	0.8±2.0	1.7±2.9

Min: Minimum; Max: Maximum; Med: Median; Q1: first quartile; Q3: third quartile; M: Mean; SD: Standard Deviation; Standing to Ground Transition: SGT.

95% CI [1.2, 7.1], d = 1.632, large) and standing to ground transition (p = 0.000, 95% CI [3.4, 9.3], d = 2.552, very large). Repeat attack showed a shorter frequency than counterattack (p = 0.000, 95% CI [1.5, 7.4], d = 1.809, large) and standing to ground transition (p = 0.000, 95% CI [3.8, 9.7], d = 2.770, very large).

For the tactical actions' effectiveness, the post hoc test confirmed differences. The direct attack presented higher effectiveness compared with the combination (p = 0.000, 95% CI [33.0, 46.0], d = 3.659, very large), counterattack (p = 0.000, 95% CI [32.3, 45.3], d = 3.286, very large), standing to ground transition (p = 0.000, 95% CI [34.0, 47.0], d = 3.579, very large), feint (p = 0.000, 95% CI [46.7, 59.7], d = 5.604, very large), and repeat attack (p = 0.000, 95% CI [45.8, 58.8], d = 5.444, very large). Feint showed a shorter effectiveness than combination (p = 0.000, 95% CI [7.2, 20.2], d = 2.514, very large), counterattack (p = 0.000, 95% CI [7.9, 20.9], d = 1.992, large), and standing to ground transition (p = 0.000, 95% CI [6.2, 19.2], d = 1.984, large). Repeat attack presented a shorter effectiveness compared with the combination (p = 0.000, 95% CI [6.3, 19.3], d = 2.269, very large), counterattack (p = 0.000, 95% CI [7.0, 20.0], d = 1.830, large), and standing to ground transition (p = 0.000, 95% CI [5.3, 18.3], d = 1.798, large).

DISCUSSION

The main findings of the current study found the dominance of direct attacks compared with other tactical actions. In its turn, there was no significant difference between direct attacks at these four tournaments. The preponderance of direct attacks corroborates the findings of previous studies. As an illustration, Polish judo athletes, Polish medallists and Croatian judo athletes produced 87.9% (Sterkowicz & Maslej, 1999), 72.9% (Sterkowicz et al., 2007), and 94.9% (Sertic et al., 2016) of direct attacks respectively. At the London Olympic Games, medallists of the category (-81 kg) carried out 78.2% (Ait Ali Yahia, 2014), whereas Japanese judo athletes performed 66.6% at the 2010 World Championships (Abdel Raouf & Abdelhalem, 2011). Arguably, throwing the opponent through a direct attack remains delicate for elite judo athletes (Kashiwasaki & Nakanishi, 1992). The brevity of the opportune moment to execute a technique justifies this complexity (Inogai & Habersetzer, 2001). As a result, pragmatism prevailed among these Olympic medallists, to the detriment of excessive risk-taking.

Although direct attacks were the most effective, other options contributed favourably to offensive activity. From the conceptual and creative standpoint, Inogai and Habersetzer (2001) have considered the indirect attack as the peak of the tactical building in a judo fight. In addition, the present study confirmed the medallists' richness of indirect tactical actions. Various configurations illustrated Olympic judo competitions. Medallists of Athens used the combination more often than counterattack, standing to ground transition, repeat attack, and feint. In Beijing and London, medallists chose the standing to ground transition more frequently than combination, counterattack, feint, and repeat attack. However, in Rio, medallists selected the combination first, followed by standing to ground transition, counterattack, feint, and repeat attack. But only standing to ground transition and repeat attack confirmed their differences. These trends resulted from the International Judo Federation's refereeing rules change, which affected the elite judo tactical approach. For illustration, Barreto et al. (2022) cited the sanction with exceptions, in 2010, of a direct attack with hands below the belt by *hansoku-make*. Since 2013, no exceptions accorded to this rule; the golden score time became unlimited, and *osae-komi* was still valid outside the area.

Besides the dominance of the direct attack, it is interesting to note that the other additional options contributed favourably to the offensive activity. Overall, the statistical analysis showed the preference of medallists for the combination first, followed by standing to ground transition, counterattack, feint, and repeat attack. International coaches argued that combinations and counterattacks are essential (Santos et al., 2015). Indeed, earlier studies validated their implication in high-level competitions. The works of Sterkowicz and Maslej (1999), Akhmedov et al. (2020), and Shavkatovich (2020) confirmed these low values of counterattacks. Contrary to expectations, Sterkowicz et al. (2007) and Boguszewski (2011) found 17.2% and 19.1%, respectively. Regarding combination, Sterkowicz and Maslej (1999) and Sterkowicz et al. (2007) highlighted 4.3% and 10.0%, respectively. The share of feint and repeated attacks has melted away; elite judo athletes grant them little interest. No work has focused on these tactical actions because of their small impact.

In terms of effectiveness, direct attack stands out in absolute dominance ahead of counterattack, combination, standing to ground transition, repeat attack, and feint. Other works confirmed the supremacy of direct attack efficiency. Thus, Sterkowicz et al. (2007) discovered 62.4%, while Mayo et al. (2019) and Ito et al. (2019) detected 82.6% and 72.6%, respectively. In 2010, to make judo more attractive, IJF changed the refereeing rules to increase the scoring of direct attacks (Samuel et al., 2019). This rule change did not significantly increase the percentage of direct attacks' effectiveness. Statistically, no difference was observed between the four competitions. Using a direct attack allows an attack with efficiency. The attacker must relieve the weak points in the defensive organisation of the adversary, such as loss of balance, inefficient control of grip, momentary muscular relaxation, and an increase in breathing rate. It is the principle of opportunity (Inogai & Habersetzer, 2001).

Further, mistakes made by elite judo athletes caused the inefficiency of direct attack, combination, and counterattack. As mistakes, Oswald et al. (2011) observed the distance from the opponent, inadequate exploitation of opportunities, loss or insufficient control of grip, body position, deficient *kuzushi* and others. In addition, an effective combination requires the analysis of the attack distances, choosing the adequate throwing speed and fixing the same one-leg position to connect various techniques (Sacripanti, 2014). A combination requires speed and good timing to change tactics fluently in a fraction of a second (Inokuma & Sato, 1986). Takahashi et al. (2005) argued that combination is the most efficient due to the difficulty of countering it. In this context, Ito et al. (2014) noted that *ashi-waza* is the appropriate technical group because it can surprise the opponent. However, the combination solicited by medallists is higher than the 11.7% reported by Ito et al. (2019).

The *judoka* must expect the adversary to attack and re-attack by choosing an appropriate technique to counter effectively (Takahashi et al., 2005). The advantage of an effective counterattack is to create more psychological pressure on the opponent (Yanlong, 2019). Moreover, the athlete must discern, perceive and expect the opponent's intentions. He should have a fast decision-making capacity to neutralise the opponent's attacks, to increase the effectiveness of both attack and counterattack (Loio Pinto et al., 2020). Olympic medallists' counterattacks are more effective than the 8.9% determined in 56 final fights (Boguszewski, 2011). However, this outcome is contrary to 17.2% and 18.8%, established respectively by Mayo et al. (2019) and Ito et al. (2019).

Also, standing to ground transitions of Olympic medallists are less effective than the 21.4% achieved by male gold medallists at the Paris Grand Slam 2017 (Pierantozzi et al., 2017). Agostinho and Franchini (2020) claimed that world champions presented a higher variation of ground transition sequences than the other medallists at the 2018 and 2019 world championships. Dopico Calvo et al. (2022) noticed that scored *tachi-waza* attacks 31.4% produced fewer ground transition sequences than unsuccessful *tachi-waza* attacks 68.6%. Therefore, the rhythm is a capital element to consider with an effective transition from standing combat to groundwork. The literature distinguished three distinct rhythms to pursue fighting on the ground: immediate, progressive and consecutive. At the 2017 World Championships, the immediate rhythm dominated the other types because of the high rate of scored *osae-komi-waza* actions. For the effective ground transition, an immediate rhythm is suitable for *osae-komi-waza*, while consecutive and progressive rhythms are appropriate for *kansetsu-waza* and *shime-waza* (Nagai et al., 2019). Rarely solicited by the Olympic medallists, feint and the repeated attack did not have the expected efficiency. Their low effectiveness is the consequence of weak frequencies.

For future competitions, coaches should consider these tactical action tendencies for improving the offensive system of their judo athletes. Indeed, the elite judo athlete must master the full range of these tactical actions, to be successful. Zadorozhna et al. (2021) confirmed that incorporating these tactical actions into their training programme, including the refereeing rules, should enhance their tactical knowledge.

Despite the relatively limited sample of elite athletes, chosen by weight category, this study is likely to contribute to our understanding of the tactical approach of Olympic medallists. The longer the fight duration, the greater the frequency of tactical actions can be. In a recent study, Ait Ali Yahia (2019) corroborated the difference in the offensive volume per fight between medallists' categories. Therefore, it should be interesting for other studies to determine the tactical profile of each weight category.

CONCLUSION

The present research has identified the tendencies of tactical actions used during these four competitions. Olympic medallists built an offensive system based on the direct attack first, followed by counterattack, combination, and standing to ground transition. These tactical actions proved their effectiveness in solving many complex defensive problems encountered in judo fights. Although feints and repeated attacks had a limited impact, their integration could be suitable, in crucial moments, to face a sophisticated defence. However, mastering a wide range of tactical actions is a capital condition for the elite judo athlete's success. Coaches should incorporate specific tasks that enhance the expertise of their athletes. These findings could improve elite judo athletes' practical approaches to tactics. Further research is required to establish how tactical actions affect success in different weight categories.

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Proximal Humerus Epiphysiolysis in a Judo Athlete

A Case With a Biomechanical Study

By Klemen Aleš Pilih[1] and Miha Fošnarič[2]

Abstract: *A case of a proximal humerus epiphysiolysis in a youth judo athlete is presented. Proximal humerus epiphysiolysis is a relatively rare injury that has been described in a classic study by Neer and Horwitz, among others. They state, "This lesion presents often enough to be of practical concern [...] and yet it is sufficiently uncommon so that few surgeons have had a broad experience with it." We believe this statement is still valid today. Although the proximal humerus epiphysiolysis does happen in a general youth population, some authors state that competitive sports predispose athletes to this type of injury. In our hospital, proximal humerus epiphysiolysis has been anecdotally connected to judo.*

For this reason, we aim to present a case of a displaced proximal humerus epiphysis injury in an adolescent judo athlete, successfully managed conservatively. With the modern video-refereeing system employed at judo tournaments, we were able to acquire the injury mechanism on video. We aim to analyse the injury mechanics and explain the forces leading to the presented injury. A discussion with a judo expert has been made about behaviour of tori and uke that ultimately led to the injury. Recommendations for injury prevention are suggested.

Keywords: *proximal humerus epiphysiolysis; treatment; prevention; video analysis; biomechanics*

Injury to the proximal humeral epiphysis is relatively rare, presenting 3 percent of epiphysial injuries (Neer & Horwitz, 1965). In their classic study, Neer and Horvitz state, "The lesion presents often enough to be of practical concern [...] and yet it is sufficiently uncommon so that few surgeons have had a broad experience with it." We believe this statement, nowadays, still holds.

Neer and Horvitz present a study on a series of 89 patients with proximal humerus epiphysiolysis, treated at the New York Orthopaedic-Columbia-Presbyterian Medical Center from 1929 until 1963. Seven of 89 patients were classified as Grade III (marked displacement with some bony contact) and 18 were classified as Grade IV (severe displacement with little or no bony contact). A 'high grade' injury was treated at their medical center with a frequency of less than one per year. The same is true for our medical department: Department of Traumatology and Orthopaedics at General hospital Slovenj Gradec, where after discussing the injury presented in this article, only a handful of such injuries were remembered; anecdotally, some in judo athletes.

Injury and Treatment

The presented injury happened in October 2022 at an international cadet judo tournament. The *uke* was a 14-year-old male competitor. *Ko-soto-gake* was performed with *tori* controlling uke's right hand poorly. During the throw, *uke* extended his right extremity to the mat. His torso was still rotating, with the right hand remaining fixed on the mat, leading to his right shoulder's retroflection. In this position, *tori* was landing over uke's torso, causing the right upper extremity to become 'locked' under the weight of both bodies falling. A strong shearing force was created from the posterolateral to anteromedial position related to the right shoulder joint.

As already described in the literature (Neer & Horwitz, 1965), the intact rotator cuff preserves the position of the humeral head in adolescents, while the diaphysis is displaced anteromedially, leading to an injury of the proximal humeral growth plate.

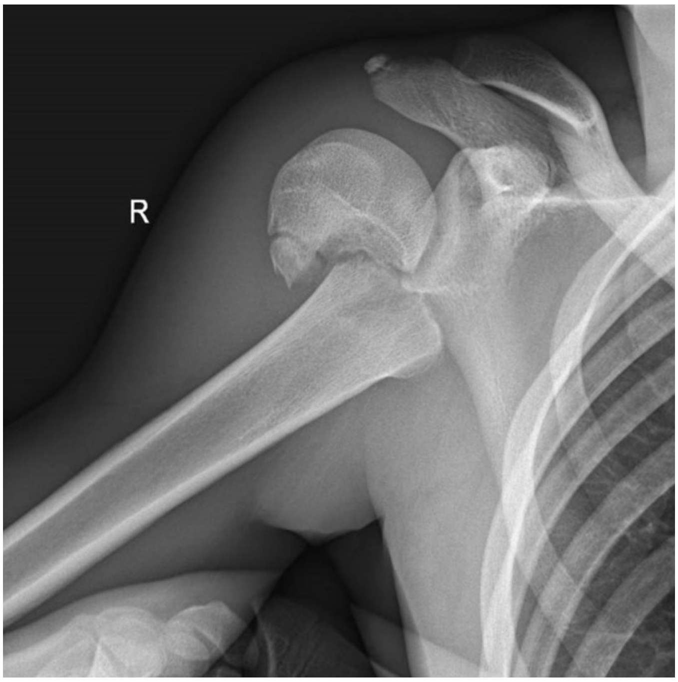

Image 1: Proximal humerus epiphysiolysis, SH 2, NH 4

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No gross deformity or neurovascular deficit of the right upper extremity was observed after the injury. Yet, the patient remained in extreme pain with locked right shoulder movements. The arm was put into a sling and the patient was taken to a regional medical centre. The X-ray diagnostics revealed the Salter-Harris Type (SH) II proximal humerus epiphysiolysis (image 1). Neer and Horvitz classify the injury according to the amount of displacement and bony contact. Grade III (NH 3) represents a severe displacement of 1/3 to 2/3 of the diaphysis. Grade IV (NH 4) means a displacement of more than 2/3 of the diaphysis or a total loss of bony contact. The injury displayed was classified as NH 4.

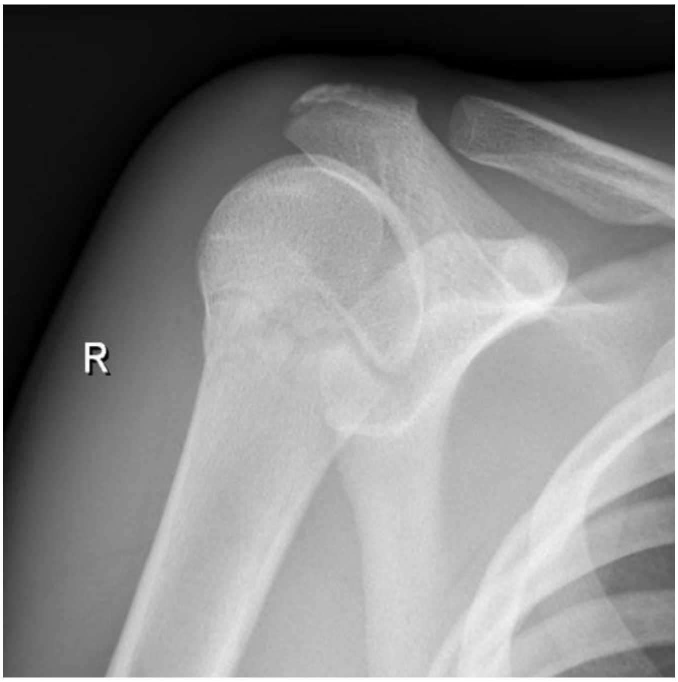

Image 2: Anatomical position after closed reduction.

The closed reduction in general anesthesia was attempted, with a good result (Image 2). The extremity was put into a Gilchrist orthosis and the patient was discharged for further treatment in his home country.

Video Analysis

Video analysis of the refereeing video material was performed, with a study of the *judoka*'s behaviour and the kinematics of the throw.

Biomechanical Analysis

A retrospective qualitative biomechanical analysis of the injury was conducted using the video footage of the fall and the radiograph of the injury. *Tori*, in the white *judogi*, appears to have pushed on *uke*, in the blue *judogi*, during the fall, with a net force (***F***), due to *tori*'s weight, inertia, and push from his legs against the ground (Figure 1). At the moment of injury, *uke*'s right arm and shoulder may have been in a 'locked' configuration – causing them to be unable to compensate for the abrupt increase in deceleration of the *tori*. Consequently, the net force (***F***) drastically increased. Since the anterior shoulder dislocation is not a predisposed injury type in adolescents, due to a strong stabilizing effect of the rotator cuff, the shear stress at the epiphyseal plate has exceeded its shear strength limit, resulting in epiphysiolysis.

Two important factors that may have contributed to the injury are worth noting:

1. Sufficient stress in the proximal part of the humerus would be unlikely to occur during the fall of only one person, making this injury quite specific to activities like judo, where multiple individuals are involved. The net force (***F***) of *tori* on *uke* may have significantly contributed to a) the shear stress at the epiphysis and b) contributed to the 'locked' configuration that disallowed significant shoulder and elbow bending to soften the impact with the ground.

2. A slightly different reaction from *uke* could have decreased the possibility of epiphysiolysis. As shown in Figure 1, *uke*'s left foot may have been in contact with the ground at the moment of injury but the configuration of his left leg may not have allowed it to compensate for most of the impact forces. The right arm may have been in a 'locked' configuration due to its sizeable horizontal abduction (extension) and almost straight elbow position, possibly contributing to the injury.

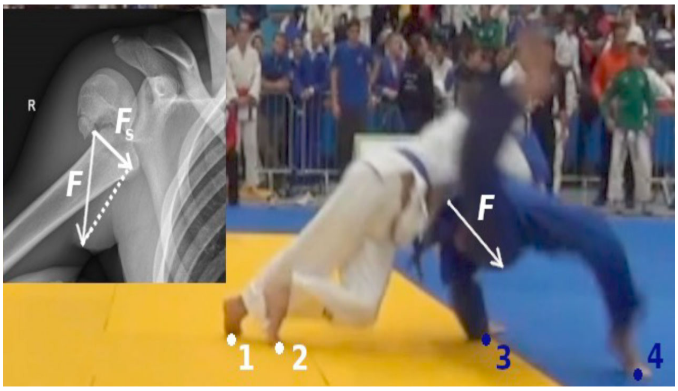

Figure 1: Snapshot from video footage capturing the moment of the fall of the *judoka*; when *uke* suffered an injury. The approximate net force (***F***) exerted by *tori* on the right shoulder of *uke* is indicated. The approximate points of contact with the ground are indicated for *tori* (points 1 and 2) and *uke* (points 2 and 3). INSET: Radiograph of the injury with indicated approximate force F and its component in the epiphyseal plate that could have caused epiphysiolysis.

1. *Tori* gains an advantage and performs the *ko-soto-gake* (Image 3).

Image 3: *Ko-soto-gake*

2. *Uke* abducts his right shoulder and extends his right upper extremity to mitigate the throw (Image 4).

Image 4: Right extremity abduction

3. With *uke* falling dorsally, his right hand reaches the mat. At the same time, *tori* is falling over *uke* ventrally, providing additional force due to gravity (Image 5).

Image 5: Hand touches the mat.

4. The right upper extremity is becoming ‘locked’ between the ground and the weight of both bodies falling (Image 6).

Image 6: Right extremity ‘locking’

5. A powerful shearing force is produced over the right upper arm, forcing the proximal humerus anteromedially. With the humeral head being stabilized by the rotator cuff, the physis is torn and the diaphysis is displaced anteromedially (Image 7).

Image 7: Injury

Professional review

A professional judo instructor has been asked to review the video material. His observations were:

1. *Tori*, when performing the technique, does not have complete control of *uke*'s right hand, leading to the ability of *uke* to abduct it. This is a minor contributor to the injury.

2. When falling, *uke* abducts and extends the right upper limb to mitigate the fall. The motive is unclear; it might be instinctive, trying to protect himself from the fall or, more likely, a competitive reflex, trying to avoid the ippon by landing on the hand. In either case, this represents a bad falling technique and is a major contributor to the injury. Such a falling technique should be discouraged during the training process.

Discussion and Conclusion

Proximal humerus epiphysiolysis is a relatively rare injury that can be clinically challenging (Schwendenwein et al., 2004). Historically, it was treated quite aggressively, with open approaches often being performed. After the Neer and Horvitz classic study, the trend shifted towards conservative treatment, with the closed reduction being conducted in more displaced cases (Neer & Horwitz, 1965). The physeal injury is usually classified as SH 1 or SH 2, meaning the tear happens in the locus minoris resitentiae, the zone of degenerating cartilage. Since the injury occurs distally to the proliferating cells and does little harm to them, it preserves the physeal growth potential. Due to the massive growth potential of the proximal humeral growth plate (80% of humeral growth happens in the proximal plate) (Baxter & Wiley, 1986), the injuries to the proximal humeral epiphysis are subject to immense remodelling. The extensive range of motion of the shoulder joint and the well-tolerated length deficit of the upper extremity is why conservative treatment results are tolerated well. The shortening of the humerus after growth cessation of up to 3 cm can be expected in more severe cases (Neer & Horwitz, 1965). The shortening is most pronounced in the 11–15-year-old group (Neer & Horwitz, 1965), which on the one hand, is not subject to as much remodelling potential as younger patients, while at the same time still expects enough growth for the growth retardation to become noticeable. The age of the patient should, therefore, be taken into consideration when treatment is determined.

In recent decades, reports have been made on successful operative treatment (Lefèvre et al., 2014; Schwendenwein et al., 2004). Also, operative treatment yields good results, indicated in cases of significant dislocation, especially with failed closed reduction. Elastic stable intramedullary nailing (ESIN) seems to be the most recommended technique (Lefèvre et al., 2014). However, classic K-wires are also used.

Although treatment outcomes with proximal humerus epiphysiolysis are generally favourable, such an injury still represents a significant delay in a young athlete's career. As always, injury prevention is the best kind of treatment. We are unaware of any data that predisposes combat sports to such injuries. However, anecdotally, in our professional environment, high-grade proximal humerus epiphysiolysis were generally connected to judo.

With the widespread use of video capture at judo tournaments, video analysis has become accessible. In a few cadet judo tournaments we have managed to follow, we noticed that most upper extremity trauma is due to falls on the outstretched hands. Generally, hand-catching is regarded as a bad falling technique, yet not only the falling technique but also the technique of the throw can be improved. With better technique, opponents can be better controlled and less unpredictable movements can be expected.

Therefore, as a step towards even fewer injuries in judo, judo coaches should encourage *judoka* to practice better falling, and also throwing technique.

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VO_{2max} Development in Children and Adolescents And its Importance in Judo

By Tin Šklebar[1], Mihovil Plečko[1], Ivan Bohaček[1,2,*]

Abstract: *Maximum oxygen uptake (VO_{2max}) serves as the gold standard for assessing aerobic fitness, representing the highest attainable rate of whole-body oxygen uptake during exercise involving large muscle groups. In judo, a physically demanding and high-intensity intermittent sport, advanced technical skills and strategic proficiency are essential for success, as athletes engage in multiple actions within time-limited matches.*

This review aimed to analyse studies comparing VO_{2max} development and trainability of trained and untrained children and adolescents in different stages of training, to determine the significance of aerobic training in judo and explore alternative training approaches for young judoka. VO_{2max} is measured using a cardiopulmonary exercise test (CPET). Training-induced increases in VO_{2max} have been observed to be influenced by factors such as increased stroke volume and greater arteriovenous oxygen content difference. The baseline values and trainability of VO_{2max} appear to be partially influenced by genetics. The development of VO_{2max} in children and adolescents follows a growth and maturation process, with age and sex-related differences observed. Trained individuals generally exhibit higher VO_{2max} values, compared to their untrained counterparts, with absolute VO_{2max} increasing linearly until around the age of 15 for both boys and girls.

In competitive judo, aerobic fitness may not be as crucial as anaerobic fitness, as elite judoka have lower VO_{2max} values compared to athletes in other endurance sports. While it is still beneficial to train aerobic fitness, the main focus for young judoka should perhaps be on developing anaerobic capacity, power, dynamic strength, and maintaining lower body fat percentages.

Keywords: *maximum oxygen uptake (VO_{2max}); judo; children and adolescent athletes; high-intensity sport*

Maximum oxygen uptake (VO_{2max}) is the highest rate of whole-body oxygen uptake achievable during exercise that utilises a large muscle mass. It is often referred to as the golden standard for determining aerobic fitness (Bundy & Leaver, 2010). The concept of VO_{2max} was first introduced in the early 1920s by the British physiologist Archibald Hill, who described it as the limit towards which the consumption of oxygen can be increased by the organism during exercise (Hill & Lupton, 1923). It is also an important determinant of endurance in athletes, with higher VO_{2max} values being strongly correlated with better performance in endurance sports such as cycling and distance running (Bassett, 2000). Similarly, it has been suggested that both aerobic power and capacity are important for optimal performance in judo, as they may help athletes maintain a higher intensity throughout the match, delay the onset of fatigue-related metabolites, and facilitate recovery between matches (Gariod et al., 1995).

Judo is a physically demanding, high-intensity intermittent sport, which necessitates advanced technical skills and strategic proficiency to achieve success (Degoutte et al., 2003). Judo contests require a significant amount of physical effort as athletes are required to perform numerous actions within a 4-minute time limit for adults and 3-minute or less for children. During international competitions, medallists typically perform five to seven contests. Since 2003, if there is an equal score, the contest enters a 'golden score' unlimited period where the first athlete to score, wins. At World Judo Tour, average contest time in 2021 amounted to 3.25 minutes (www.ijf.org) typical of activity followed by 5 to 10 seconds of rest.

AIM

The aim of this review is to analyse the results of studies that have conducted physiological and performance measurements of children and adolescents in different stages of training and studies measuring the same parameters of untrained children and adolescents, in order to compare their VO_{2max} development and trainability. The goal is to enhance our comprehension of the physiology of judo and determine whether aerobic training is truly an important component of judo or should the focus of young *judoka* instead be on some other form of training.

AEROBIC AND ANAEROBIC FITNESS

Physical fitness consists of cardiorespiratory endurance, muscular strength, muscular endurance, balance, speed, flexibility and body composition, which are all important for maintaining overall physical health and reducing the risk of chronic diseases, and a comprehensive fitness programme should include exercises targeting each of these components (Vanhees et al., 2005).

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The importance of aerobic fitness and physical fitness in general shouldn't be understated as multiple studies have shown that alterations in physical fitness serve as a reliable predictor of mortality (Blair et al., 1989). A study observed a significant decrease in mortality risk in healthy middle-aged men with even minor enhancements in physical fitness (Erikssen et al., 1998). Aerobic fitness in children is also inversely related to total adiposity, waist circumference, and visceral and abdominal subcutaneous adipose tissue, suggesting that regular physical activity is important to improve aerobic fitness and in turn reduce abdominal adiposity in the youth (Lee & Arslanian, 2007). Moreover, a study has shown that in children and adolescents, aerobic fitness is more strongly associated with cardiovascular risk factors than objectively measured physical activity components (Hurtig-Wennlöf et al., 2007). High values of the physical activity variables were associated with a favourable cardiovascular profile, with aerobic fitness being the main contributor (Hurtig-Wennlöf et al., 2007).

The metabolic sources that provide the energy necessary for sustaining physical activity are critical to understanding the metabolic demands of a particular sport. There are two metabolic sources, aerobic and anaerobic. Aerobic metabolism relies on the presence of oxygen to produce ATP, while anaerobic metabolism does not require oxygen and produces ATP more rapidly, but less efficiently (Lumb & Thomas, 2020). The balance between these two systems varies depending on the intensity and duration of the activity, as well as the athlete's individual fitness level. Sports with high-intensity, short-duration efforts, such as sprinting or weightlifting, rely heavily on anaerobic metabolism. In contrast, endurance sports such as distance running, rowing or cycling rely more on aerobic metabolism (Joyner & Coyle, 2008). Understanding the specific metabolic demands of a sport is crucial for developing appropriate training programmes, nutritional strategies and other interventions that can enhance athletic performance. While anaerobic metabolism is crucial for decisive actions in judo, such as explosive movements, aerobic fitness also plays an important role in high-intensity intermittent exercise (Tomlin & Wenger, 2002). In addition, aerobic fitness has also been linked to a quicker recovery following high-intensity intermittent exercise (Farzaneh Hesari et al., 2014). An article explains how to assess the differential contribution of energy systems in sports that are difficult to reproduce in controlled laboratory conditions, using judo as an example (Artioli et al., 2012). In the article physiological parameters were measured at rest and during and after exercise to collect oxygen consumption data, also processing and calculating of blood samples was done to determine peak plasma lactate. It was then possible to calculate the energy expenditure and the contribution of each energy system, thus presenting oxygen consumption during various stages, including at rest, during exercise, and after exercise. Interestingly, while anaerobic contribution appears to be dominant, the aerobic energy system amounted to about 40% of the total energy expenditure during the exercise.

ABSOLUTE AND RELATIVE VO_2

VO_2 (or oxygen consumption) can be measured and reported in either relative or absolute terms. Absolute VO_2 is expressed in litres per minute (L/min) and represents the total amount of oxygen consumed by an individual during exercise. This measure is influenced by an individual's body weight, muscle mass and metabolic rate (Powers & Howley, 2015). Relative VO2, on the other hand, is expressed in millilitres of oxygen per kilogram of body weight per minute (ml/kg/min) and is often used to compare individuals of different body sizes. This measure takes into account an individual's body weight, making it a more accurate reflection of an individual's oxygen consumption per unit of body weight.

VO_{2max} LIMITATIONS

During an incremental exercise test, VO_{2max} is identified as the peak value achieved despite the progressive increase in the applied load, accompanied by a plateau in the VO_2 curve (Herdy et al., 2016). VO_{2max} is limited by the ability of the cardiorespiratory system to deliver oxygen to the exercising muscles. This can be explained using the Fick equation. The Fick equation is a mathematical relationship that describes the rate of oxygen uptake by the body. It states that maximum oxygen uptake (VO_{2max}) is equal to the product of maximal cardiac output (Q max) and the maximal arteriovenous oxygen difference (a-vO_2 $diff_{max}$). The a-VO_2 diff represents the difference in the oxygen content of arterial blood and venous blood, which reflects the amount of oxygen extracted by the tissues (Skattebo et al., 2020). Several factors can impact the availability of oxygen, including the capacity of the blood to carry oxygen, which depends on the amount of hemoglobin available, as well as the arterial oxygen saturation level (SaO_2) and changes in the dissociation curve due to temperature, carbon dioxide levels, and pH. Additionally, cardiac output, consisting of heart rate (HR) and stroke volume (SV), can also influence oxygen availability, as can the redistribution of blood flow throughout the body (Marciniuk et al., 2013). The amount of oxygen extracted by the tissues also plays a crucial role, which is influenced by factors such as capillary density, mitochondrial density and function, adequacy of perfusion, and tissue diffusion (American Thoracic Society & American College of Chest Physicians, 2003). However, studies suggest that the main limiting factor of VO_{2max} is maximal cardiac output (Shephard et al., 1968). Currently, it is understood that the typical range of VO_{2max} values seen in sedentary and trained individuals of the same age is primarily influenced by differences in maximal stroke volume. This is because there is relatively little variation in maximal heart rate and the body's ability to extract oxygen from the blood.

There are multiple limitations to Fick's equation, including its inability to account for muscle fibre type, lactate threshold, as well as assuming a homogeneous distribution of oxygen consumption throughout the body. For example, a study found that muscle fibre type and lactate threshold were important determinants of VO_{2max} in trained endurance athletes and should be considered in addition to Fick's equation when estimating VO_{2max} (Lucia et al., 2003). Another limitation of Fick's equation is that it assumes a constant arteriovenous oxygen difference (a-vO_2diff) throughout exercise which may not always be the case. A study found that the a-vO2diff was not constant during incremental exercise in untrained individuals, but rather increased progressively with exercise intensity (Jones et al., 2010). Another study found that the arteriovenous oxygen difference was significantly influenced by age and fitness level, and varied between different modes of exercise (DeLorey et al., 2004). One more limitation of Fick's equation is that it assumes a linear relationship between oxygen consumption and work rate, which may not be accurate at higher work rates (Gaesser & Poole, 1996). This can result in overestimation of VO_{2max} at very high work rates.

TESTING VO_{2max}

VO_{2max} is typically tested during a cardiopulmonary exercise test (CPET) which involves the individual performing incremental exercise while breathing through a mask that measures oxygen and carbon dioxide levels. During CPET, several parameters are measured including oxygen uptake (VO_2), carbon dioxide output, ventilation, heart rate, blood pressure, electrocardiogram, respiratory quotient, oxygen saturation (SpO_2), and pulmonary function tests such as forced vital capacity and forced expiratory volume in one second. The VO_{2max} is measured during a maximal exercise test, typically using a treadmill or a cycle ergometer, where the individual is pushed to their maximal effort. The criteria for achieving maximal effort include a plateau in VO_2 with increasing work rate, a respiratory exchange ratio >1.15, and a heart rate within 10 beats/min of age-predicted maximal heart rate. The highest 30-second average VO_2 achieved during the test is considered VO_{2max} (American Thoracic Society & American College of Chest Physicians, 2003)

The main differences in VO_{2max} measurement between adults and children during exercise testing are due to age-related differences in physiology and differences in exercise tolerance (Cooper et al., 1984). Children tend to have a higher VO_{2max} relative to their body size, faster VO_2 kinetics at the beginning of exercise, and while adults generally require a plateau to confirm VO_{2max}, children may reach VO_{2max} without a plateau (Rowland, 1993). Children also have a higher peak heart rate during exercise, but lower stroke volume. Additionally, they may have a higher ventilation rate relative to their VO_2 when compared with adults. The most commonly used treadmill protocol for CPET in children and adolescents is the Bruce protocol (Chang et al., 2006). However, it may be easier to measure important physiological parameters such as electrocardiogram and blood pressure during exercise and achieve an accurate assessment of maximal work rate using a cycle ergometer instead of a treadmill. The Godfrey protocol is often used for CPET with a cycle ergometer in young children due to the speed of the treadmill protocol being a restrictive factor (Godfrey, 1974).

An article discusses how children with chronic conditions often have reduced levels of aerobic fitness due to disease-related pathophysiology, treatment (e.g., medication), hypoactivity, and deconditioning (Takken et al., 2017). This puts them at greater risk of preventable health problems like obesity and cardiometabolic diseases. Pediatric exercise testing is used to compose individually tailored exercise training programmes for these children. By participating in individualised physical exercise training, their aerobic fitness can significantly increase, improving their overall health and well-being (Takken et al., 2017).

BASELINE VO_{2max} HEREDITABILITY

There is strong evidence to suggest that genetics plays a role in determining an individual's baseline VO_{2max}. The heritability of VO_{2max} refers to the proportion of variation in VO_{2max} that can be attributed to genetic factors. A study measured VO_{2max} in 53 pairs of monozygotic twins, 33 pairs of dizygotic twins, and 42 non-twin brothers, who were all between 16 and 34 years old and engaged in regular physical activity (Bouchard et al., 1986). The study found that the baseline heritability of VO_{2max} was approximately 40% in their sample, which suggests that genetic factors accounted for about half of the variation in VO_{2max} among the participants. The study also found that the within-pair similarity of VO_{2max} was slightly higher for the monozygotic twins compared to the dizygotic twins and non-twin brothers, indicating that genetic factors played a larger role in determining aerobic performance in the former group (Bouchard et al., 1986).

VO_{2max} TRAINABILITY

A study aimed to investigate the contribution of stroke volume and oxygen extraction towards the training-induced increase in VO_{2max} in healthy older men and women (Spina et al., 1993). The results showed that training increased VO_{2max} by 19% and 22% in men and women, respectively, and that the increase in stroke volume accounted for 66% of the increase in VO_{2max} in men, while the entire increase in VO_{2max} in women was due to a greater arteriovenous oxygen content difference (Spina et al., 1993). In another study, eight participants exercised six days a week for 40 minutes a day for a total of ten weeks. VO_{2max} increased by an average of 5% during the first week, and endurance, VO_{2max}, and time to attainment of peak heart rate increased linearly over the ten weeks. The average weekly increase in VO_{2max} was 0.12 l/min, with a total increase of 16.8 ml/kg per min (44%) (Hickson et al., 1977). However, those results were obtained from fairly sedentary subjects and it is widely believed that as an individual becomes more fit, it becomes progressively harder to elicit further VO_{2max} improvement and the intensity of exercise would need to continuously increase if any further gains are to be achieved. It is believed that the most effective way to increase VO_{2max} is through regular cardiovascular exercise that challenges the body's oxygen utilisation capacity (Helgerud et al., 2007). While for the average untrained person regular training intensity of above 50-60% of VO_{2max} is sufficient to see improvement, we can only speculate on how much the training intensity would have to increase for elite athletes to achieve the same percentage of improvement.

ROLE OF GENETICS IN VO_{2max} TRAINABILITY

To determine whether genetics play a role in VO_{2max} trainability, a study was conducted involving 10 pairs of monozygotic twins of both sexes who underwent a 20-week endurance-training programme (Prud'homme et al., 1984). The programme involved training four to five times a week in 40 minute sessions at an average of 80% of maximal heart rate reserve. The study found that training significantly increased maximal aerobic power (MAP) by 12% of the pre-test value, with mean changes in ventilatory aerobic and anaerobic thresholds reaching 20% and 17%. The intraclass correlation analysis revealed that the sensitivity of MAP to the training was largely dependent on genetics, with an intraclass correlation coefficient of 0.74 ($P<0.01$), indicating that individuals from the same twin pair showed similar responses to training. A different study, the HERITAGE Family Study, was a large-scale investigation into individual differences in response to a standardised endurance exercise programme, as well as the role of familial aggregation (Sarzynski et al., 2022). The study involved over 700 participants from 130 families and utilised a standardised exercise program and extensive physiological and genetic measurements. The results showed that VO_{2max} training response had a significant heritability of approximately 47%, with maternal heritability reaching 28%, indicating that genetics play a substantial role in determining one's trainability of VO_{2max} (Sarzynski et al., 2022). Those results are coherent with another study that investigated the correlation between baseline VO_{2max} and VO_{2max} in response to training within and among families (Bouchard et al., 1999). The difference of the response of age-and-sex-adjusted VO_{2max} was 2.5 times larger among families, as opposed to within families, indicating a degree of familial resemblance in the trainability of VO_{2max}. Furthermore, some families mainly exhibit low-response phenotypes, while others display large concentrations of high responders to training (Bouchard et al., 1999).

VO_{2max} DEVELOPMENT IN UNTRAINED CHILDREN

In children, VO_{2max} develops just like other processes related to growth and maturation during childhood and adolescence. However, there are some age and sex-related differences. A study aimed to create percentile curves for aerobic fitness in American adolescents aged 12 to 18 years. The study used a large, nationally representative sample (n=2997) and included both boys and girls from different racial backgrounds (Eisenmann et al., 2011). The results showed there was a modest increase in estimated VO_{2max} of boys between ages 12 to 15 and then it stagnates, while in girls, there was a minor decrease in estimated VO_{2max} between ages 12 to 18. The study also found that boys had higher values compared with girls at every age-specific percentile (Eisenmann et al., 2011). Similarly, another study provides age-and-gender-specific standards for VO_{2max} that have been adjusted for body weight in children and adolescents (Bongers et al., 2014). Presenting a VO_{2max} range for boys aged 8 to 18 of 40.3-63.3 ml/kg/min and a range of 33.6–55.6 ml/kg/min in girls of the same age group. These standards can be used as a benchmark for evaluating the aerobic fitness of children and adolescents (Bongers et al., 2014).

VO_{2max} DEVELOPMENT IN CHILDREN IN TRAINING

Cote and Hay proposed, in their book, three age categories for children's involvement in sports, based on their developmental perspective (Cote & Hay, 2002). First is the sampling stage, which is for children aged 6-12. During this stage, children should participate in a variety of sports activities, with an emphasis on enjoyment and fun rather than competition. Children should not specialise in a single sport but rather have the opportunity to experience different sports and develop their basic skills. The second stage is the specialising stage, which is for children aged 13-15. At this stage, children start focusing on one or two sports and begin developing more specialised skills in those sports. However, it is still important for them to continue participating in other physical activities to maintain a well-rounded fitness level. The third stage is the investment stage, which is for athletes aged 16 and older. In this stage, athletes have already identified a primary sport and start to invest more time and effort into their training and competition. They begin to specialise in specific positions or events within their sport and may have a more structured training regimen. A practice model is particularly relevant to the investment stage and is a deliberate practice model of expertise consisting of a training approach that emphasises intentional and focused effort, intending to improve specific skills or abilities. Athletes are encouraged to engage in deliberate practice, which involves breaking down complex skills into smaller components and practising those components repeatedly. Athletes are also encouraged to receive feedback from coaches or other experts and use that feedback to adjust their training and improve their performance.

Unlike in adults, there has been relatively little research investigating how VO_{2max} responds to training in children and adolescents. A 2016 literature review compared the absolute VO_{2max} values in children and adolescents reported in all the studies reviewed (Helmantel et al., 2016). To establish baseline values for absolute VO_{2max}, they used data from studies that did not have a training programme and from the beginning of training programmes in the studies that had an intervention, and these values reflect the normal growth of VO_{2max}. Sports used for training in the studies were endurance sports such as swimming, basketball, interval running and cycling. The results indicate that absolute VO_{2max} increases almost linearly until around 15 years of age, at which point girls seem to reach a plateau while boys continue to improve. Trained children and adolescents generally show higher VO_{2max} values than untrained peers of both sexes but the rate of increase in VO_{2max} does not appear to differ across age (Helmantel et al., 2016).

The same study also compared the corresponding values for relative VO_{2max}. The results indicate that trained children and adolescents tend to have higher relative VO_{2max} values compared to their untrained peers. Overall, relative VO_{2max} values seem to improve during the sampling years but tend to remain stable during the subsequent stages in both sexes. There is a slight increase in relative VO_{2max} in males during the investment years, while a minor decrease was observed in females (Helmantel et al., 2016).

To sum up, in the sampling years, both trained and untrained children experience improvements in absolute VO_{2max} ranging from 3% to 20%. Only two longer lasting (52 and 78 weeks) studies reported improvements exceeding 30% in absolute VO_{2max} (Obert et al., 1996; Vamvakoudis et al., 2007). However, larger improvements in these studies were partly due to growth and maturation, as control groups also showed high improvements, ranging from 14.5% to 24.2% over the same period.

AEROBIC FITNESS IN JUDO

In theory, aerobic fitness is important in judo due to the high-intensity intermittent nature of the sport. Improved aerobic capacity can lead to faster recovery during short rest periods, help maintain a higher intensity during matches, and delay the accumulation of metabolites associated with fatigue processes (Di Domenico & Raiola, 2021). Additionally, it helps reach a steady-state fat percentage of 7–10%, which could translate to improved athletic performance in judo (Franchini et al., 2011).

A study was conducted to compare the physical fitness of judo athletes and non-athletes aged 11-17 years and to assess their body's functional adaptation (Jaszczanin et al., 2017). The study involved 47 judo athletes and 48 untrained schoolchildren, measuring their aerobic and anaerobic capacity. The results showed that power indicators increased in all groups, but judo athletes had significantly higher anaerobic capacity than non-athletes. Judo athletes also showed an increase in lactic acid concentration, heart rate alterations, and pH changes during simulation fights, with differences depending on age, training and experience. However, no significant differences were observed in VO_{2max} between the two groups. Anaerobic performance indicators were significantly better in judo athletes compared to untrained peers.

An article reviews the current world records for maximal aerobic and anaerobic power in elite athletes in various endurance sports, including runners, cyclists, rowers and cross-country skiers (Haugen et al., 2018). These athletes are considered to be at the upper human limits for aerobic power. The review found that male cross-country skiers, cyclists and runners have VO_{2max} values of around 90 ml/kg/min. Women's values are slightly lower, around 80 ml/kg/min in cross-country skiers and runners.

Those values are significantly higher than those of elite *judoka* found in a study measuring VO_{2max} values of elite *judoka* from multiple international competitions where their VO_{2max} values ranged from 44.5 to 57.2 ml/kg/min (Torres-Luque et al., 2016). Such differences in VO_{2max} values of elite athletes, as well as results from aforementioned studies, would perhaps suggest that aerobic fitness is not as important for success in competitive judo as anaerobic fitness. Even comparing these VO_{2max} values to the values of children and adolescents, we can see that the estimated value range of VO_{2max} in elite *judoka* fits inside the normal range for untrained children. Interestingly, the relative VO_{2max} of elite *judoka* even falls short of the trained boys.

Another study found that successful judo athletes tend to have low body fat levels, except for heavyweight athletes (Franchini et al., 2011). Male athletes tend to have a predominance of mesomorphy, while female athletes have similar components of mesomorphy and endomorphy. High-level competitive judo athletes possess highly developed dynamic strength, muscular endurance, anaerobic power and capacity, and aerobic power and capacity, with upper body variables being more prominent than lower body variables. Muscle power was better developed in the lower body, while isometric grip strength was only slightly above average compared to the non-athlete population. However, aerobic power and capacity were not highly developed in these athletes.

CONCLUSION

VO_{2max} baseline values, as well as trainability are strongly age and genetics related. While VO_{2max} certainly is trainable, the results indicate that aerobic capacity isn't highly developed in elite judo competitors. Also, the rate of increase in VO_{2max} appears not to differ across ages. This suggests that beginning training at a younger age during the sampling years does not limit the increase in VO_{2max}

during the older specialising and investment years. However, during the specialising and investment years, improvements tend to be lower (absolute VO_{2max} increase from 3% to 14% and relative VO_{2max} from 3% to 10%) in trained youth than in the sampling years, but the data on this matter is lacking. While young *judoka* should certainly develop aerobic fitness as it is still a major component of judo and helps with recovery, results suggest that it perhaps need not be the main training focus. The fact that the relative VO_{2max} of elite *judoka* is lower than that of trained boys could again speak in favour of judo primarily being an anaerobic sport, as the sports used for training in those studies were aerobic endurance sports. Therefore, training focus should primarily be on anaerobic, power and dynamic strength increasing exercises rather than focusing on aerobic power and capacity. This means that for young judo athletes aiming to succeed at higher levels of competition, the primary focus should be on maintaining lower body fat percentages of about 7-10%, while also developing dynamic strength, muscular endurance, anaerobic power and capacity, muscle power in the lower extremities and isometric grip strength.

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Characteristics of Severe Judo-Related Neck Injuries in Japan

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Abstract: *Recently, serious judo-related injuries have become a social problem in Japan and there is a strong interest in preventing cervical spinal cord injuries that could result in severe sequelae. We aimed to clarify the characteristics of severe judo-related neck injuries in Japan and to consider appropriate counter-measures. We retrospectively investigated individuals who had made claims to the All Japan Judo Federation's System for Compensation for Loss or Damage, for the rate of severe judo-related neck injuries. The estimated rate of severe neck injury (per 100,000 people) with the uchi-mata technique, which was the most common, was 0.86 for high school students, which was significantly higher than that of the other groups ($P < 0.01$). Among those with < 5 years of judo experience, uchi-mata caused most injuries, but among those with 10–15 years of judo experience, the types of techniques varied widely. In the group with < 5 years of experience, the main cause was considered to be a lack of skill, for which the instruction of kuzushi may be beneficial. For the group with 10–15 years of experience, we believe that there were injuries that were difficult to prevent due to the unpredictable forces from the dynamic movement of the two judoka working with and against one another, as is expected when people with considerable muscle strength grapple each other and perform techniques. Our findings provide insight into judo-related neck injuries, which can help in the creation of appropriate preventative measures.*

Keywords: *judo; neck injury; severe injury; spinal cord injury; fracture/dislocation of neck*

Judo is a martial art that was founded by Kano Jigoro Shihan in 1882. Judo aims to train one's mind and body. Judo is now an official Olympic event and is one of the most widely played international sports in the world, with 200 countries belonging to the International Judo Federation. Judo was designed to be practised safely but because the game is won by throwing or knocking down the opponent, injuries occur quite frequently (Pocecco et al., 2013). In recent years, serious judo-related injuries have become a social problem in Japan and there is a strong interest in preventing cervical spinal cord injuries that could result in severe sequelae (Kamitani et al., 2017).

The aim of this study was to clarify the characteristics of severe neck injuries in judo in Japan and to consider counter-measures.

SUBJECTS AND METHODS

In this study, a severe neck injury was defined as an injury in which the cervical vertebrae were fractured or dislocated and/or had residual neuropathy. Neuropathy was defined as residual paralysis for ≥ 6 months. Cases involving individuals who had made claims to the All Japan Judo Federation's (AJJF) System for Compensation for Loss or Damage were retrospectively investigated. Under this system, members registered with the AJJF are paid compensation in the event of death or serious, irreversible, functional disability during judo competition-related activities. The survey observation period was from April 2003 to December 2021. Cases that could not be followed up for > 6 months after injury were excluded from the study. During this period, 64 neck injuries were reported to the AJJF, of which 45 met the definition of a severe neck injury.

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The survey variables were gender, age at the time of injury, years of experience, grade, injury status, mechanism of injury, presence or absence of fracture, dislocation, and/or neuropathy, and whether or not surgery was performed. In addition, the number of people registered in the AJJF was investigated so that the rate of severe neck injury (hereinafter referred to as the injury rate) was calculated.

The number of registered AJJF members (All Japan Judo Federation, 2020) was extracted for each category of elementary school students, junior high school students, senior high school students, university students, and adults. Injury rates per 100,000 people were presented with two-sided 95% Pearson-Cropper confidence intervals according to the exact binomial distribution and changes in annual injury rates over time were investigated. Pearson's chi-square test was used to compare whether injury rates per 100,000 people differed between categories. Since this was a descriptive observational study, no adjustment for multiplicity was made. The significance level was set at 5% two-sided.

RESULTS

Of the 45 cases of severe neck injury, 39 were male and six were female. The median age at injury was 16 years (9–16 years). The number of cases by category was as follows: one (2%) elementary school student or younger, 12 (27%) junior high school students, 23 (51%) senior high school students, one (2%) university student, and eight (18%) adults (Fig. 1). The estimated injury rate per 100,000 people was 2.2 for senior high school students, which was statistically significantly higher (P < 0.01) than any other groups.

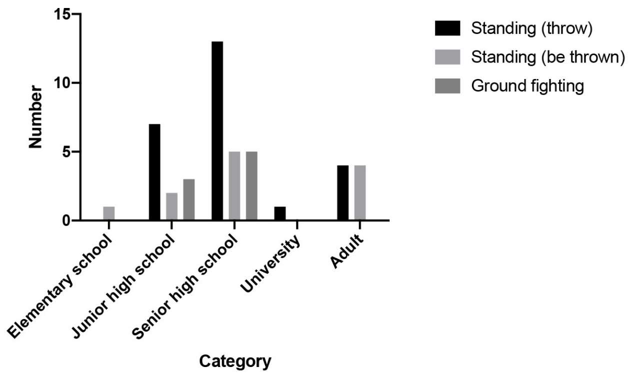

Figure. 1: The number of cases by category

The median years of experience was 7 years (0.1–40 years). There were 10 cases unranked (22%), 25 cases in the first rank (*shodan*) (56%), four cases in the second rank (*nidan*) (9%), three cases in the third rank (*sandan*) (7%), two cases in the fifth rank (*yondan*) (4%), and one case in the sixth rank (*rokudan*) (2%). Furthermore, 29 cases were injured during games, and 16 cases were injured during practice.

As for the mechanism of injury, 37 cases were caused by standing throws and 8 cases were caused by ground fighting. The breakdown of standing throws was 25 cases when doing the technique and 12 cases when receiving the technique. As for the types of technique performed, 16 cases involved uchi-mata, two involved *sode-tsuri-komi-goshi*, two involved *harai-goshi*, two involved *ko-uchi-makikomi*, one involved *o-uchi-gari*, one involved *kata-guruma* and one involved *seoi-nage*. On the other hand, as for the types of technique received, three cases involved *seoi-nage*, one involved the *uchi-mata*, one involved the *o-goshi*, one involved the *sukui-nage*, one involved the *sasae-tsurikomi-goshi*, one involved the *sode-tsurikomi-goshi*, one involved the *harai-goshi*, one involved the *kaeshi-waza*, one involved the *kubi-nage*, and one involved the *ko-soto-gari* (Table 1). The estimated rate of severe neck injury (per 100,000 people) for *uchi-mata*, which was the most common, was 0.86 for high school students, which was significantly higher than that for the other groups (P < 0.01). The estimated rates of severe neck injuries from *uchi-mata* for other groups were as follows: The junior high school student was 0.05, the university student was 0, and the adult was 0.26, respectively.

Table 1: The types of technique

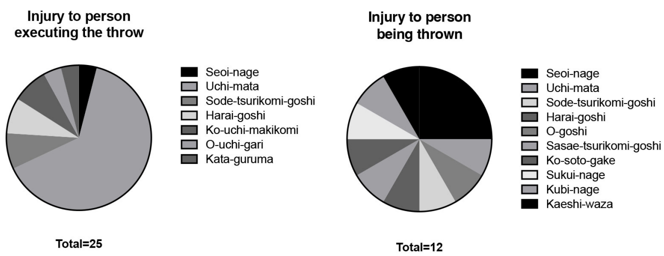

Figure 2 shows the mechanism of injury stratified by years of judo experience. Although the number of cases was not large, no clear trend could be found, but the same trend was observed among those with < 5 years of experience and those with 10–15 years of experience who were more likely to be injured when performing techniques. As for the types of technique, 11 cases were *uchi-mata* and one was harai-goshi among those with < 5 years of experience. On the other hand, those with 10–15 years of experience had *uchi-mata* in two cases, sode-tsurikomi-goshi in two cases, ko-uchi-makikomi in two cases, harai-goshi in one case, and kata-guruma in one case.

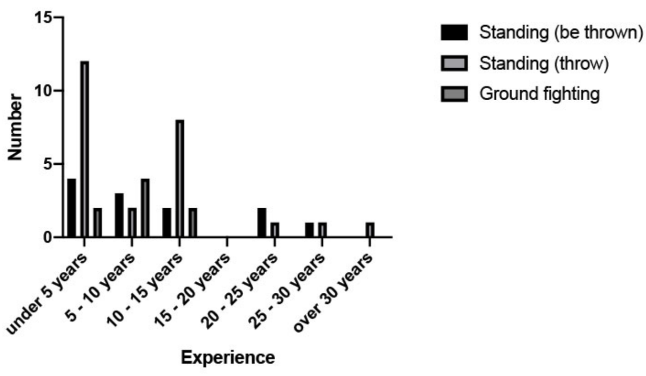

Figure. 2: The mechanism of injury stratified by years of judo experienc

There were 23 cases of fracture/dislocation with neuropathy, 15 cases of fracture/dislocation without neuropathy and seven cases of neuropathy without fracture/dislocation. Surgical therapy was performed in 33 cases, and conservative treatment was used in 12 cases. Figure 3 shows the rate of severe neck injuries each year. The confidence intervals generally overlapped and no obvious increase or decrease was observed.

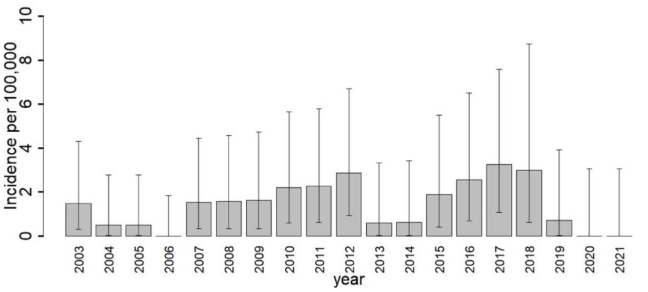

Figure 3: The rate of severe neck injuries each year

DISCUSSION

According to a survey report (Miyakoshi et al., 2021) on cervical spinal cord injuries in Japan in 2018, sport accounted for only 3.1% of all injuries. However, sport accounts for 43% of injuries among teenagers, so it is very important to clarify the causes of injuries and take counter-measures. Skiing, cycling, snowboarding, rugby, surfing, gymnastics, and judo have been reported as causes of sports injuries (Chan et al., 2016). In this study, we investigated severe neck injuries caused by judo.

A judo contest lasts only four minutes, plus a period of extra time in some cases. However, in the context of severe neck injuries, more accidents occur during game time than during practice, which is much longer than the game. We believe that there were many cases in which the desire to win was strong in the game and that there were many cases in which the player was injured by using techniques in an unreasonable posture compared with those used during practice.

In terms of injury mechanism by age of experience, there were many cases in which injuries occurred when performing techniques among those with < 5 years of experience and those with 10–15 years of experience. We previously reported that severe neck injuries were more common in those with ≥ 3 years of experience (Kamitani et al., 2013). However, in this study, there were two peaks in years of experience, and it was clear that the type of technique that caused the injury was different.

Based on the above results, we will discuss the prevention of severe neck injuries. The causes are presumed to be different between the group with < 5 years of experience and the group with 10–15 years of experience.

For the group with ≤ 5 years of experience, the main cause of injury was a lack of skill. As for the mechanism of injury, there were many cases in which the head landed on the tatami from the top of the head when *uchi-mata* was applied. The reason for this may be that the unbalancing technique of judo, *kuzushi*, was insufficient. *Kuzushi* refers to the movement of the opponent's body back and forth and left and right to destabilise their posture when performing a technique. An opponent can only be thrown when they are put in an unstable position. Landing on the top of the head may be due to the player's pivot foot being unstable; however, the biggest problem may be that *kuzushi* is insufficient. In other words, in order to apply *uchi-mata* when the opponent's centre of gravity is stable, we believe that it was deflected by the opponent with the player landing on the top of their head. A decrease in the number of injured people in this group can be accomplished by technical guidance. In particular, it is important for them to learn the basic movements of *kuzushi*.

On the other hand, in the group with 10–15 years of experience, there were no definite trends in the technique that caused the injury. Compared to the group with < 5 years of experience, this group has mastered the basic skills of judo, so it is unlikely that the cause is a lack of skill. We believe that there were cases that were difficult to prevent because of the unpredictable forces produced by the weight of the two judoka being moved dynamically, when people with muscle strength grapple each other and perform techniques.

In order to reduce the incidence of neck injuries, judo has rules that help avoid dangerous situations. According to the rules of the International Judo Federation (International Judo Federation, 2017), landing on the top of the head while applying a technique or deliberately when being thrown (head defence) in order to prevent the opponent from scoring by landing on one's back, is prohibited and is deemed a serious violation. In Japan, the referee explains the rules before the match and warns that landing on the top of the head is considered a serious offence, resulting in the player losing by disqualification. However, no significant changes in the injury rate were observed over time. Various media, such as videos, may help promote understanding through visual aids in conjunction with verbal communication. It is also important to take measures that focus on senior high school students, who have a particularly high injury rate.

In 2013, the AJJF introduced an official Judo Instructor Qualification System. Under this system, all instructors must attend classes in order to acquire and regularly renew their licence to teach judo safely. In the future, it will be necessary to enhance these workshops.

This study is based on data from the AJJF Damage Compensation and Consolation Payment System. In order to participate in matches in Japan, both athletes and instructors must be registered with the AJJF; therefore, we believe that most injury cases can be extracted from this data. However, the database does not include unregistered athletes who practise judo, such as those who do not participate in competitions or those injured in school classes, which is a limitation of our study. Therefore this can be a small fraction of the real figure. Although a study examining judo accidents that have been conducted in Japan, it does not necessarily cover all cases (Nimura et al., 2022).

Another limitation is that the reporter to the AJJF was the judo instructor rather than the medical doctor who treated the injuries. Information about the situation obtained by AJJF staff while directly interviewing the reporter might have contained medically inaccurate information.

CONCLUSION

The primary conclusions of this study are as follows:

- In terms of the mechanism of injury, there were many cases in which injuries occurred when performing techniques among those with < 5 years of experience and those with 10–15 years of experience.
- In the group with < 5 years of experience, *uchi-mata* caused most of the injuries, but in the group with 10–15 years of experience, the types of techniques varied widely.
- In the group with < 5 years of experience, the main cause was considered to be a lack of skill and improved instruction of *kuzushi* may be beneficial.

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Loss of Consciousness in Judo: Similarities and Differences Between Traumatic Brain Injury and Choking Techniques (*Shime-Waza*)

By Kabir Singh Lota[1,2], Nikos Malliaropoulos[2,3,4], Mike Callan[5], Akira Ikumi[6]

Abstract: *Loss of consciousness (LOC) is a critical event that can occur in judo as a result of both traumatic brain injury (TBI) and choking techniques (shime-waza). This research note explores the similarities and differences between these two distinct causes of LOC, in the context of judo. The aims are to further knowledge surrounding these phenomena, provide additional insight into the underlying mechanisms and emphasise the importance of safety and risk management in training and competition.*

Firstly, the research note explores and compares the underlying physiological mechanisms through which TBI and shime-waza can cause LOC. The short and long-term consequences of both instances, as well as the significance of repeated injuries on player health, and considerations for safety and risk management strategies in the sport suggested by governing bodies are discussed.

A comprehensive understanding of the similarities and differences between LOC caused by TBI and shime-waza is vital in order to increase awareness amongst players, coaches, officials, and researchers alike. Thus, appropriate precautionary measures regarding player safety can be implemented in judo, and allow those who participate to continue enjoying the sport to its full extent.

Keywords*: loss of consciousness; shime-waza; traumatic brain injury*

Judo is a combat sport and education system developed from a grappling martial art which was created in 1882 by Jigoro Kano (Bennett, 2009; Lota, Błach, et al., 2022). Its practice involves techniques that require both physical skill and mental discipline. However, Pocecco et al (2015) noted that players face potential injury risks, such as loss of consciousness (LOC), resulting from traumatic brain injury (TBI) and specific choking techniques (*shime-waza*). This research note explores the similarities and differences between TBI and *shime-waza*, concerning loss of consciousness in judo. An understanding of these aspects is vital in order to enhance safety measures, training protocols and subsequent risk management strategies.

Traumatic Brain Injury in Judo

TBI refers to a complex pathophysiological process affecting the brain, caused by external biomechanical forces to the body (McCrory et al., 2017). In judo, potential injury situations include throws, falls and direct clashes. The acceleration-deceleration forces generated during an impact subject the brain to rapid movements within the skull, resulting in physiological and neurological disruption, including LOC. Rotational acceleration (RA) is more strongly implicated in TBI and the amount of damage is thought to be proportional to the degree of acceleration experienced (Lota, Malliaropoulos, et al., 2022). Indeed, the risk of TBI and LOC is greater with impacts generating higher RA values (Lota, Malliaropoulos, et al., 2022).

Several mechanisms contribute to LOC in TBI. It is, primarily, the abrupt movements of the brain upon impact that can stretch nerve fibres, thus altering neural communication networks and causing transient LOC. The impact from TBI can also directly affect areas of the brain responsible for consciousness, such as the reticular activating system, which is located in the brainstem (Arguinchona & Tadi, 2019). Cerebral oedema (and associated intracranial hypertension) may occur following TBI, which (as well as being

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important contributors to morbidity and mortality rates after injury) cause herniation, increase intracranial pressure, decrease perfusion pressure and compromise oxygenation, due to mass effect (Zusman et al., 2020). Oxygenation could also be compromised by the initial impact, with alterations in blood flow leading to the inadequate delivery of oxygen to the brain, thereby resulting in LOC.

Choking Techniques (*Shime-Waza*) in Judo

Shime-waza, or choking techniques, form an integral part of judo's technical repertoire. Such manoeuvres involve the application of pressure to the neck, primarily targeting the regional blood vessels. The arms, collar and legs of tori (the attacking player) can be used in shime-waza to settle a contest by way of opponent submission, or eventual LOC, using techniques such as *hadaka-jime* (rear naked choke) and *gyaku-juji-jime* (reverse cross strangle) (Sasaki et al., 2022). When carried out properly, LOC may occur within 10 to 20 seconds (Koiwai, 1987). Players are also thought to resume consciousness spontaneously approximately 12 to 15 seconds after choking release (Rodriguez et al., 1991). *Shime-waza* is generally considered safe; however, the consequences of incorrectly performing these techniques can be severe.

The exact mechanism of LOC resulting from *shime-waza* remains unclear. Compression of the carotid artery can cause LOC due to a restriction in cerebral blood flow. This has been evaluated and confirmed using techniques such as sonography, Xenon isotopes, and spectrum analysis (Rau et al., 1998; Reay & Holloway Jr, 1982; Rodriguez et al., 1991; Sasaki et al., 2022). Similarly, airway obstruction could result in LOC due to the reduced oxygen supply to the brain. Other proposed theories include, carotid sinus stimulation, vagus nerve stimulation and jugular vein compression (Sasaki et al., 2022). Carotid sinuses are located within carotid arteries (the primary blood supply to the brain) and pressure on these sinuses stimulates stretch receptors and triggers the carotid sinus reflex. This leads to reflex bradycardia and systemic vasodilation, which, in turn, decreases blood flow to the brain and can cause LOC (Andani & Khan, 2020). The vagus nerve has an important role in various bodily functions. Increased vagal stimulation also causes a reflex bradycardia and lowers systemic blood pressure as a result of decreased cardiac output, which may result in LOC too (Jeanmonod et al., 2017). Compression of the jugular vein during *shime-waza* can increase intracranial pressure and consequently decrease cerebral perfusion pressure (the difference between mean arterial pressure and intracranial pressure) (Sasaki et al., 2022; Stellpflug et al., 2020). Adequate perfusion pressure maintains blood flow to the brain, therefore LOC can occur when this is insufficient (Stellpflug et al., 2020).

Similarities, Differences and Long-Term Consequences

The main similarity between TBI and *shime-waza* appears to be the potential for injury and LOC. Both carry inherent risks in judo, however the mechanisms described above are significantly different. TBI does not always cause LOC; rather, LOC may occur immediately following an unintentional and substantial impact. TBI can otherwise cause short-term symptoms such as headache, dizziness, nausea, confusion and memory impairment, with symptoms persisting for up to ten days (Lota, Malliaropoulos, et al., 2022). Recovery following TBI can vary according to symptom severity, although a period of rest, avoidance of activity, followed by a gradual return-to-play is generally recommended.

Shime-waza, on the other hand, can cause a relatively rapid, but gradual and intentional, LOC if *uke* does not submit. Should LOC occur, it is accepted that players quickly regain consciousness and functionality upon release of the *shime-waza*. Unlike TBI, this is without persistent neurological symptoms once awake (Stellpflug et al., 2020). An important consideration regarding *shime-waza* concerns the interaction between training partners or the presence of a referee in competition. Players are rarely rendered unconscious in chokehold situations as verbal or non-verbal signals by *uke* should trigger release of the chokehold, prior to possible LOC. Additionally, referee intervention requiring chokehold release at the instance that a player becomes unconscious is prompt. Writing about mixed martial arts, Lim et al (2019) suggested that prolonged periods of brain oxygen deprivation associated with chokeholds can cause hypoxic-ischaemic brain injury. Whilst theoretically possible in judo, this could only happen in a situation "where the competitors or referee were acting in a completely nonstandard fashion" (Stellpflug, 2019).

The long-term consequences of TBI and *shime-waza* are contrasting. Repeated LOC following TBI can cause mild cognitive impairment, including difficulties with memory, attention, concentration and information processing. Post-concussion syndrome (PCS) describes the persistence of symptoms such as headache, fatigue and visual disturbances, beyond three months (Permenter et al., 2018). Players are at increased risk of PCS after more than one brain injury. Repeated LOC, particularly in the context of recurrent head trauma, has been associated with an increased risk of developing chronic traumatic encephalopathy (CTE). CTE is a progressive neurodegenerative disease characterised by the accumulation of abnormal tau protein in the brain (Lucke-Wold et al., 2014). Features of CTE include cognitive decline, behavioural changes and mood disorders and other motor impairments. The relationship between TBI and CTE in sport is now accepted and the supporting evidence base continues to grow. Rotational acceleration in head impacts causing LOC is thought to be greater and may be considered more significant in the development of CTE. Of course, this is not to say that TBI is excluded when players retain consciousness following an impact, and repetitive subthreshold impacts are of equal importance when considering its progression (McKee et al., 2016). LOC and TBI has also been associated with the development of other neurodegenerative conditions such as Alzheimer's disease (and other forms of dementia), and Parkinson's disease.

Conversely, any long-term effects of LOC from *shime-waza* are relatively unknown. Recovery from LOC is largely instantaneous and critically there is no current literature linking repeated LOC from choking techniques to neurological sequelae, or conditions such as CTE and hypoxic-ischaemic brain injury. As discussed, in the instance of LOC, a rapid return to consciousness and normal functionality following chokehold release implies that players can be choked-out multiple times without consequence (Stellpflug, 2019). This is not true for LOC and TBI, which carries a cumulative injury risk (Bramlett & Dietrich, 2015). Additional research is certainly required to explore this relationship further; however, for the time being it seems reasonable to suggest that repeated LOC from shime-waza is unlikely to result in any significant long-term outcomes.

Safety Considerations and Risk Management

Given the potential injury risks of TBI and *shime-waza* in the context of LOC in judo, it remains essential to prioritise player safety in all situations and implement effective risk management strategies. Proper technique and training under the close supervision of qualified coaches is crucial for players of all levels to minimise the risk of TBI and ensure the safe application of *shime-waza*.

LOC is sometimes an unintended consequence of throws and falls, which should always be taught correctly. Similarly, players must continue to practise and employ correct *ukemi* (breakfall) techniques, as these help to prevent direct head contact with the mat upon landing (Lota, Malliaropoulos, et al., 2022). There remains discussion surrounding the efficacy of under-mats in judo to lower head impact forces (Maruyama et al., 2017).

The proper application of *shime-waza* should not cause significant injury. The literature has only one case of carotid artery occlusion and right middle cerebral artery territory infarction recorded (Kato et al., 2017). By 1987, no deaths had been reported due to *shime-waza* in over a century of judo practice, since its inception in 1882 (Koiwai, 1987). Although, the alleged use of choking techniques (whether correctly or incorrectly) in scenarios outside of judo resulted in a number of fatalities (Koiwai, 1987). Whilst it is unrealistic to expect such situations to arise in judo training or competition, this reinforces the need for all players to receive thorough instruction and precise execution and control of *shime-waza*. Extra consideration is also given to younger and older age groups, who are prohibited from using certain choking techniques.

Prompt recognition, assessment and appropriate rehabilitation is essential following LOC in judo. In both instances, players are immediately removed from competition (Nimura et al., 2022). The British Judo Association (Banks & Eyres, 2022) provide detailed protocols on managing LOC from TBI and *shime-waza* in players younger than 18 years, and 18 years or older. It is recommended for all players to be assessed by a medical professional. LOC after TBI necessitates mandatory rest periods followed by a graduated return-to-play, with specific requirements at each level. In younger players, this is conducted carefully over four weeks, compared to only two weeks in older players, with specific requirements at each level. Players who suffer LOC during *shime-waza* are advised to complete a shorter period of rest and generally to not need to complete a return-to-play protocol.

CONCLUSION

In judo, TBI and *shime-waza* can lead to LOC in players of all ages, albeit through different mechanisms. However, the causes, intent and degree of control differ significantly. An appreciation and understanding of the similarities and differences in the context of LOC allows players, officials, coaches and researchers to take appropriate precautions, implement safety measures, promote responsible training practices and direct future research. Prioritisation of player health and adherence to proper techniques in judo helps to minimise the risks associated with LOC and ensure a safe environment where players can continue to enjoy the benefits of the sport.

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INDUSTRY VIEWPOINTS

The Impact of the Covid Pandemic on the Injury Rate at Europe's Top Level Judo Tournaments

By Peter Smolders

Abstract: *Since 2005 the EJU Medical Commission has collected data on injuries happening during top-level events all over Europe. Results were published in a previous edition of this journal. When in early 2020 our judo lives came to an abrupt halt with different kinds of lockdowns in all the countries of Europe, we were very concerned about what this would mean in terms of training possibilities, preventative exercises and potentially an increase in the number of injuries. In Europe the EJU Anti-Covid Taskforce worked tirelessly to try to restart all judo events. With the help of the IJF Covid Protocol, slowly but surely, we were on the right track. Extensive testing, creation of 'judo bubbles,' isolation and quarantine, helped the judo world back to its feet. Tournaments and training camps came back but our major concern remained: were our judoka well enough prepared for top-level events or would all this result in an increased injury rate?*

Keywords: *impacts; Covid-19 pandemic; injury rate; top-level judo tournaments; Europe*

METHODS

With the restart of the judo events, our injury registration also restarted. With the same injury registration forms as before and the large database we already compiled, we aimed to measure the impact of the pandemic and its lockdowns on injury statistics. The injury registration form was filled in by local medical teams with the help of an EJU Medical Commissioner, who was always present.

RESULTS

We define our post-lockdown period as the period between the lockdown of March 2020 until the end of 2022, during which EJU organised 31 events, both continental cups and continental championships. These 31 events had a total of 11118 participants and 162 injuries. (table 1)

	Pre-lockdown	Post-lockdown	Total
number of events	126	31	157
participants	28297	11118	39415
injuries	693	162	855
% injured	2.44%	1.46%	2.17%

Table 1: Overview of number of injuries

We realise that it is very difficult to compare the long pre-lockdown period, of more than 15 years, with a relatively short post-lockdown period, but the post-lockdown injury rate of 1.46% of judoka needing medical intervention appears lower than the pre-lockdown rate of 2.44%. The least we can conclude is that the covid pandemic lockdown did not cause an increase in injury rate during competition.

We also always look at the serious injuries. We define a serious injury as an injury which requires the judoka to be transported to hospital. In table 2 it is shown that pre-lockdown 0.48% of participants needed to be transported to hospital and post-lockdown this rate was 0.35%. There is no statistically significant difference.

	Pre-lockdown	Post-lockdown	Total
participants	28297	11118	39415
serious injuries	135	39	174
% injured	0.48%	0.35%	0.44%

Table 2: Overview of number of serious injuries

We can also compare the number of injuries in each weight category pre- and post-lockdown. Table 3 compares the women's weight categories. Due to the small datasets, making a comparison is extremely difficult, but the distribution of injuries seems to follow the distribution of participants.

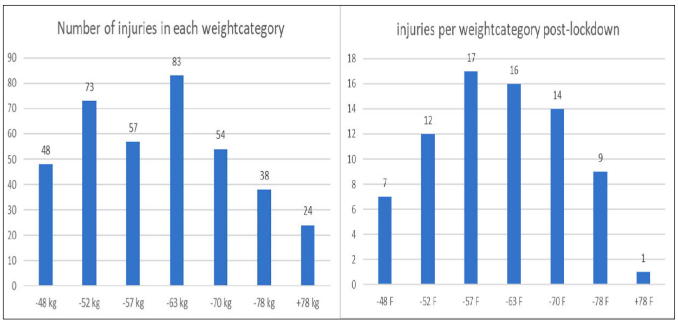

Table 3: Comparison of number of injuries in the women's weight categories

Author's affiliation: EJU Medical Commission

The comparison in the men's weight categories (table 4) seems to suggest that, post-lockdown, the lighter weight categories suffered more injuries, but the small datasets make a real statistical analysis almost impossible.

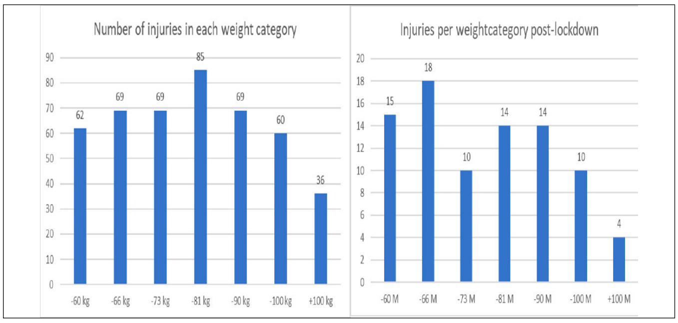

Table 4: comparison of number on injuries in the men's categories

During injury registration the anatomical location of the injury is always registered. This is shown in Table 5. We see a remarkable difference in shoulder injuries. Pre-lockdown 15% of all injuries were located at the shoulder joint. Post-lockdown this was no less than 25%. Neck injuries rose from 7% pre-lockdown to 14% post-lockdown.

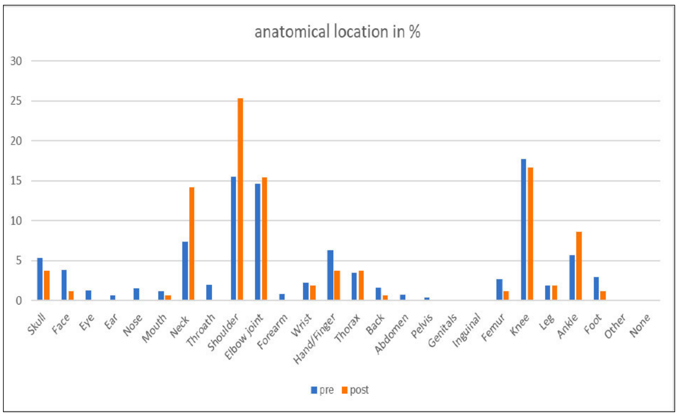

Table 5: Distribution of number of injuries per anatomical location.

CONCLUSIONS

The main fear of the medical staff of all judo teams all over the world was that due to the covid-pandemic restrictions, the preparation for high-level competitions would be hampered, resulting in an increase in the number of injuries. We are happy to announce that this fear did not come to fruition, although the comparison of very different datasets remains challenging. The least we can conclude is that the injury rate did not increase. This might suggest that a lot of judoka used their time without social occasions to employ preventative training techniques and core stability training.

The very difficult statistical analysis of those different datasets may also show some indications of an increase in number of injuries at the shoulder joint and the neck region.

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Judo for Neurofibromatosis

Coping with a chronic disease with physical, cognitive and behavioural difficulties

By Lan Kluwe[1], Hannes Daxbacher[2], Regina Daxbacher[3] and Said C. Farschtschi[1]

Abstract: *Neurofibromates are a distinct group of neurocutaneous disorders that are characterized by nerve sheath tumours, bone deformities, pain and neuropsychological conditions. Complicating malignant transformation of predominantly benign tumours can occur. Patients with neurofibromatosis experience to a high extend social stigmatization unmet medical needs. Within the 13th nationwide NF lay-organization Meeting Bundestagung Neurofibromatose the opening lecture was held from Sensei Regina and Hannes Daxbacher discussing positive effects of sport in general and Judo for chronic disease and proposing ideas for specific research on this issue*

Keywords: *judo; neurofibromatosis; schwannomatosis; chronic disease; stigmatization; tumour*

BRIEF REPORT

Judo is not limited to *tatami*. It can be taken in many other areas and inspires new ideas and approaches. For example, in helping to cope with neurofibromatosis type 1 (NF1), a genetic disease with various cognitive and behavioural difficulties.

Neurofibromatosis (NF) describes a group of rare genetic diseases which are characterized by multiple tumours. Among these diseases, neurofibromatosis type 1 (NF1) is the most common one affecting approximately 1 in 3000 new-borns, fulfilling the criteria for a rare disease. Although rare it still is a frequent condition. For comparison, the down syndrome caused by the trisomy 21 has an almost comparable incidence. NF1 can cause a wide variety of symptoms ranging from tumour-manifestations, neuropsychological conditions and bony deformities. Malignancies and cerebrovascular disease can occur at high rates and are responsible for a significantly higher mortality in patients with NF1. The less frequent schwannomatosis (NF2, 1 in 25000, other schwannomatosis subtypes 1 in 69.000) is characterized by brain and spinal tumors which often cause deafness and blindness as well as severe neurological deficits or pain. Neurofibromatoses most severely affect skin and nervous system (neurocutaneous disorder). What all of these diseases have in common is that they are still subject to a high level of social stigmatization. The extend of this fact is illustrated in the motion picture The Elephant Man by David Lynch (1980). Because of the variety of symptoms and the off-putting appearance patients with NF1 experience to be the "poor cousin of medicine".

Besides the tumour symptoms, NF1 patients have various cognitive and behavioural problems, which severely affect their quality of life. These problems are especially pronounced in children and adolescents with NF1 and cause great distress to the patients and their parents. The IQ of NF1 children is lower than that of non-NF1 children and more than half of the NF1 children have attention-deficits. Consequently, a majority of NF1 children have poorer school performance and difficulties in peer relationships. Visuospatial and motoric impairments are also common in NF1 children, further worsening the situation.

The German Neurofibromatosis Society (Bundesverband Neurofibromatose) is a nationwide lay organization in Germany with around 2000 active members and member families. The Society represents NF patients and their families, links them to special medical care, provides educational materials, medical information, encourage exchange of experience among members and improve social acceptance. The Society organizes a meeting for their members every three years where medical professionals specialized in NF are invited to explain treatment options, development of new therapies and scientific findings. These experts answer questions from patients, parents and other family members.

Dr. Said Farschtschi is the Chairman of the German Neurofibromatosis Society, a neurologist who heads the Neu-

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rofibromatosis Center at the University Medical Center Hamburg Eppendorf, the largest and most comprehensive one in Europe. Being a judo black belt, Dr. Farschtschi took part in competitions in Italy and had a judo trip to Japan with the police sports club in Königsbrunn. His personal, positive experiences in judo left Dr Farschtschi to think about a connection between judo and medicine, in this case neurofibromatosis. “Judo is almost predestined for participation in the area of chronic diseases and social exclusion.... Everyone is trainable and the body and mind can develop significantly.” Especially for NF1 children with deficits in strength, coordination and attention, judo training is expected to help. In fact, Judo is virtually ideal as an integrational activity. As an athletic sport it trains physical strength, core stability and coordination. Taking responsibility for another person, namely uke, makes it even more valuable as it bases on trust and reliability during exercise. These characteristics make Judo not only an athletic activity than also a tool for social functioning. This is underlined by the international judo values and the judo codex, a universally valid set of rules that facilitate social interaction and participation. Inspired by the words of Judo-Sensei Ichiro Abe “If you fall six times, you have to get up seven times” Judo can be an important part of every-day resilience, a crucial source for coping mechanisms when living with a chronic disease.

For the German NF meeting in 2023 in May, Dr. Farschtschi invited his former coach Johannes Daxbacher and his wife Regina Daxbacher to give an opening talk where principles and values of judo were introduced followed by several Judo-related relaxation exercises (*Taiso*). The participants of the meeting were interested and had fun in following these unfamiliar exercises. However, everybody was able to follow and to experience the power of judo. The great response came not only from the patients, but also the attending medical professionals including neurologists, paediatricians, surgeons and oncologists. The idea “Judo for NF1” was born. That opened the horizon for projects in the near future. For example, a comparative study can be designed with two groups of approximately 10 NF1-children with attentional deficits, one group will participate regular judo training for one year, while the kids in the other group as references do not join the activity. A panel of psychological tests will be carried out for these 20 NF1 kids, before, during and after the one-year Judo-training. Such a study will provide us evidence whether or not judo will significantly improve various parameters as well as subjective general health and mental being of NF1 children. In any case, we are confident that judo will positively influence life of children, adolescents, and adults with or without NF1.

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