



THE ARTS AND SCIENCES OF JUDO



AN INTERNATIONAL INTERDISCIPLINARY JOURNAL
Vol. 02 No. 01 2022

„The Arts and Sciences of Judo“

Interdisciplinary journal of International Judo Federation

Vol. 02 No. 01 2022; ISSN 2788-5208

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Publisher: IJF Academy Foundation (Malta, Ta Xbiex)

Co-publisher: International Judo Federation (IJF)

Layout: Nicolas Messner, IJF Media

Front page: Nicolas Messner



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Do Neck Strength and the Force Acting on the Body Correlate to Head and Neck Stabilisation During the Breakfall for *Osoto Gari*?

By Sentaro Koshida^{1,2}, Takanori Ishii^{2,3}

Abstract: Neck stabilisation during a breakfall, in response to a judo throw, may play a crucial role in preventing direct contact between the participant's head and the judo mat. Therefore, neck strength may predict the risk of judo-related head injuries. However, the precise association between neck strength and neck stabilisation during breakfalls remains to be clarified. Furthermore, the effect of the impulsive force during breakfall on head and neck stabilisation has not been discussed in previous research studies. Therefore, the aim of our study was to investigate the correlation between neck strength, the force acting on the body during *osoto gari*, and head and neck stabilisation parameters. Thirty novice male judoka volunteered to participate in this study. Three-dimensional motion analysis of *osoto gari* breakfalls was performed to obtain biomechanical variables such as the resultant linear and angular head acceleration during breakfall, the force acting on the whole-body centre of mass (COM), as well as the isometric neck strength. A multiple regression analysis was performed to elucidate the contribution of neck strength and impact force on head and neck stabilisation ($P < 0.05$). Our results demonstrated no significant correlation among the peak neck flexion strength, the peak force acting on the COM, the peak linear and the peak angular acceleration of the head during breakfall. The present finding suggests that neck strength may not be a useful parameter in screening for high risk head injuries in novice judoka. Therefore, a mere enhancement of the neck strength and/or a reduction in the magnitude of the impulsive force imposed during *osoto gari* may not be fully effective in preventing judo related head injuries.

Keywords: *biomechanics; injury and prevention; head concussion; martial arts*

Prevention of head injuries sustained during sports activities remains an important issue that must be addressed by sports medicine professionals. Notably, severe head injuries sustained during judo activities have gained public attention in Japan (Nambu & Noji, 2014; Hitosugi, Murayama, Motozawa, Ishii, Ogi-no & Koyama, 2014). The All Japan Judo Federation has reported that at least 55 cases of severe head injury, including acute subdural hematoma, occurred during judo practices or competitions between 2003 and 2019 in Japan (All Japan Judo Federation, 2020). Apart from severe head injury cases, mild traumatic brain injuries (MTBIs) are more common in judo (Pocecco, Ruedl, Stankovic, Sterkowicz, Vecchio, Garcia, et al., 2014; Frey, Lambert, Vessele, Rousseau, Dor, Marquet, L.A., et al., 2019). For instance, Miyazaki et al. reported that approximately one-third of high level judoka had experienced at least a single episode of MTBIs during their athletic career (Miyazaki, 2012). It is noteworthy that head injuries occurred most frequently among judoka with <3 years of judo experience (Kamitani, Nimura, Nagahiro, Miyazaki, & Tomatsu, 2013). Therefore, coaches and sports medicine practitioners need to focus on novice judoka primarily, to facilitate enhanced judo related injury prevention.

Although the exact injury mechanism is still unclear, most researchers have agreed that direct and hard contact of the occipital area of the head with the judo mat is the predominant mechanism of judo related head injuries (Nishimura, Fujii, Maeyama, Saiki, Sakata, Kitamura, 1988; Nagahiro, Mizobushi, Hondo, Kasuya, Kamitani, Shinbara, et al., 2011). Epidemiological findings have also demonstrated that being thrown backwards with *osoto gari* was the most common situation producing head injuries (Kamitani et al., 2013). Several biomechanical studies have previously reported that *osoto gari* applies more significant loading to the head segment of judoka than other throws (Hashimoto, Ishii, Okada, & Ito, 2015; Koshida, Ishii, Matsuda, Hashimoto, 2017a; Ishikawa, Anata, Hayashi, Yokoyama, Ono, et al., 2018). Furthermore, the peak angular momentum of the head and neck segment during sudden neck extension at the point of breakfall has been reported to be significantly greater in novice judoka than in the more experienced ones (Koshida, Ishii, Matsuda & Hashimoto, 2017b). In fact, this may be associated with a more significant number of head injuries occurring in novice judoka using *osoto gari*. Therefore, the biomechanical characteristics of whiplash-like neck motion during breakfalls may play an essential role in head injury occurrences sustained in judo.

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Nonetheless, current evidence indicates that isometric neck strength is associated with neck stability in response to perturbation loading, hence it may be a useful screening tool for sports-related head injuries. When considering the underlying injury mechanism, neck strength may also play a significant role in head injury prevention in judo practice and competition. This could be explained by the fact that neck strength may enhance the respective protective properties which could help to withstand direct contact between the occipital area of the head and the judo mat during breakfalls. However, the potential association between the neck muscle strength and the risk of such judo related head injury needs to be carefully considered. Limited scientific evidence supports the relationship between neck strength and head and neck stabilisation (Flao, Brughell, Hume & King, 2019). Koshida et al. also reported that there was no significant linear correlation found between the isometric neck flexion strength and peak neck angular momentum during breakfalls for *osoto gari* in novice male judoka (Koshida, Ishii, Matsuda & Hashimoto, 2017c). Furthermore, this study has also indicated that when judoka are thrown with *osoto gari*, bodily contact with the judo mat is bound to occur prior to the sudden head and neck extension (Koshida et al., 2017c). This in turn suggests that the force acting on the body during breakfalls could be transmitted to the head and neck segment and subsequently facilitate a resultant whip-like motion. Therefore, it is reasonable to assume that the greater the forces acting on the body during the judo throw, the greater and more significant their impact is on neck biomechanics during judo breakfalls. However, the authors failed to report or define the magnitude of force acting on the body during the throw and this was not considered in the subsequent analysis. Therefore, the aim of this study is to investigate whether the isometric neck strength and the impact on the body from an *osoto gari* throw contribute to head and neck stability during breakfalls with novice judoka.

METHOD

Participants

The three-dimensional trajectory data of 20 participants included in Koshida et al. were included in this study (Koshida et al., 2017c). In addition, we recruited twelve novice male judo practitioners who had no previous experience of judo competition. All participants attended at least ten sessions of the judo class offered by the university and were taught basic judo breakfall techniques from the same instructors. Participants had no previous history of musculoskeletal injuries in their head and neck region or traumatic head injuries at the time of measurement. One participant did not complete the required measurements and his data was therefore excluded from the subsequent analysis. We obtained written informed consent from all participants after notifying them about the purpose and the risks related to our study. This study was approved by the ethics committee of the Faculty of Health Sciences, Ryotokuji University.

Data Collection

41 reflective sponge markers (diameter: 2.5 cm) were placed on the anatomical landmarks of the participants: the anterior superior iliac spines, greater trochanters, medial/lateral knees, medial/lateral malleolus, heads of the 1st and fifth metatarsals, calcaneal tuberosities, distal phalanx of the 1st digit of the feet, medial/lateral epicondyles of the femur, lateral costal borders (10th rib), anterior/posterior shoulder, manubrium of sternum, thoracic vertebrae in a straight line in the horizontal plane from the sternal marker, medial/lateral elbow joints, medial/lateral wrists, and the 3rd metacarpal heads of the hands, ears, and top of head. Participants were asked to wear tight-fitting spandex shorts, judo clothes designed to improve visibility of the attached markers (Ishii, Ae, Kobayashi, & Suzuki, 2012) and headgear to ensure safety during the respective measurements.

The measurement protocol involved three sets of breakfalls for *osoto gari* on the mat, performed by a tester (the thrower) who had >20 years of judo experience and a 3rd Dan black belt. The standing height and body mass of the thrower was 1.70m and 64 to 66kg, respectively. The thrower was also left-handed and the participants performed only one side of the breakfall motion.

Three-dimensional marker trajectory data (500 Hz) was obtained with a 12-camera Mac3D motion analysis system (Motion Analysis Corp., Santa Rosa, CA, USA). Consequently, this data passed through a low-pass filter (Butterworth digital filter) with a 15 Hz cut-off frequency. We performed data reduction and data processing using a video processor/computer system (Cortex software, Version 3.04, Motion Analysis Corp., Santa Rosa, CA, USA). All data was analysed with MATLAB (MATLAB R2017b, The Mathworks Inc., Natick, MA, USA).

Data Analysis

We used the 15-segment coordinate system that consists of the following: head, right/left upper arms, right/left forearms, right/left hands, upper trunk, lower trunk, right/left thighs, right/left shanks and right/left feet. We estimated the centre of each segment and the centre of mass (COM) of the whole body using body segment parameters for Japanese athletes (Ae, 1996). The resultant linear and angular acceleration of the head segments in the breakfall for *osoto gari* were calculated in order to represent neck stabilisation during breakfalls for *osoto gari*, assuming that lower peak linear and angular acceleration would indicate greater neck stabilisation (Hrysomallis, 2016). The head segment coordinate system was defined as follows: the z vector was defined from the clavicle marker to the head segment centre. We then created a supplementary vector from the left ear to the right ear markers. The cross product of zhead vector and shead vector was defined as yhead vector and the cross product of zhead and yhead vector was defined as xhead vectors (Figure 1). The resultant angular acceleration around the head segment centre was calculated by differentiating head segment angular velocity with respect to time. Finally, whole-body COM was

calculated as the resultant COM acceleration times body mass to assess the impact on the body during the break-fall motion. Furthermore, the resultant COM acceleration was calculated by differentiating COM displacement with respect to time (for two consecutive times). Figure 2 illustrates the typical manifestation of the resultant linear head acceleration, resultant head angular acceleration and the force acting on the whole-body COM. The mean values of the three trials were used for further analysis.

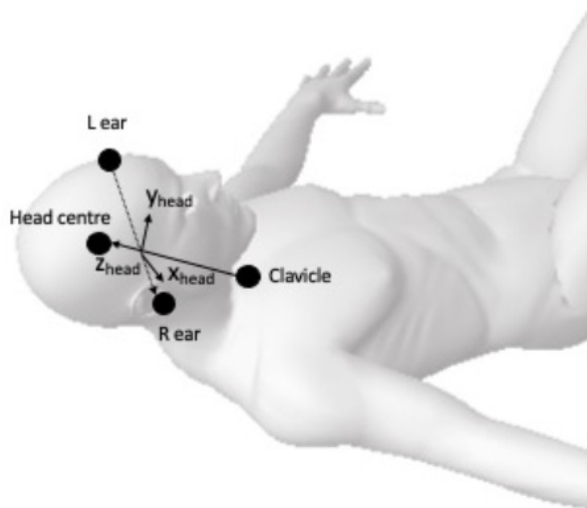


Figure 1. Head segment coordinate system: Black circles represent the markers and the dotted arrows represent the x, y, z coordinate vectors of the head segment

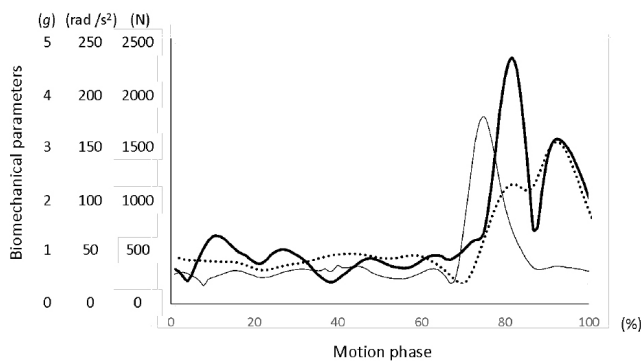


Figure 2. Typical representation of the head linear acceleration (g), head angular acceleration (rad/s²) and the force acting on the whole body centre of mass (N) during breakfalls for osoto gari

The motion starting from the moment when the thrower's leg initially made contact with the participant, until the time when the participant's head reached its lowest position on the vertical axis, was normalised to 0 to 100 %. Moreover, the dotted line represents the linear acceleration of the head, whereas the bold line represents the angular acceleration of the head and the fine line represents the force of the whole body centre of mass (Figure 2).

Figure 3 shows the isometric neck muscle strength measured using a handheld dynamometer (μ Tas F-1, Anima, Tokyo). All measurements were performed by an experienced tester with >15 years of experience as a certified healthcare provider. All participants were initially placed in the supine position on the bed with a neck flexion angle of 20 degrees. After participants were secured to the treatment table using straps at the level of trunk, pelvis, thighs and shanks, the tester placed the handheld dynamometer on the foreheads of participants. Consequently, the tester gradually applied force to the forehead until participants could no longer maintain their initial head and neck position. A pillow was placed at the back of participants' heads for safety reasons throughout this measurement process. The mean values of the two trials performed were then used for data analysis and the extraction of significant and accurate findings.



Figure 3. Neck flexion isometric strength measurement. White arrow represents the direction of the applied force

Statistical Analysis

Statistical analysis was performed with the free statistical software R.version3.4.4 for Macintosh. First, we performed the Shapiro-Wilk normality test to confirm the normal distribution of each variable. We then used the Smirnov-Grubbs test to detect outliers if the normality of the data was confirmed. Two multiple regression analyses were then performed with the peak head linear and angular accelerations as the dependent variables, respectively. On the other hand, the peak neck flexion strength and the peak force acting on the whole body COM were defined as the independent variables in both analyses. Statistical significance was set at $P = 0.05$.

RESULTS

The Smirnov-Grubbs test detected significant outliers in the linear acceleration data in one participant. Therefore, a total of 30 participants' data was used for the analysis. Mean \pm standard deviation of age, standing height, body mass, body mass index, and peak isometric neck flexion strength were 20.1 ± 0.9 years, 1.72 ± 0.1 m, 67.2 ± 7.7

kg, 22.7 ± 2.5 kg/m², 124.0 ± 23.9 N, respectively. The intra-subject repeatability of the neck flexion strength was ICC = 0.82, which is considered to be accurate and reliable.

Table 1 exhibits the peak head linear and angular acceleration and the peak COM force during breakfalls for *osoto gari*. The multiple regression analysis showed that peak isometric neck flexion strength and peak COM force did not correlate significantly with either the peak resultant head linear acceleration ($F = 0.85$, $df = 2$, $P < 0.43$) or the peak resultant head angular acceleration ($F = 2.45$, $df = 2$, $P = 0.11$).

Table 1. Biomechanical parameters during breakfalls for *osoto gari*

Biomechanical parameters during the breakfall	N = 30
Peak resultant head linear acceleration(g)	3.3 ± 0.7
Peak resultant head angular acceleration(rad/ s ²)	259.2 ± 146.3
Peak COM force (N)	2232.6 ± 433.9

Discussion

The present study indicates that isometric neck strength may not be a significant determinant of head and neck stabilisation during breakfalls. The whiplash-like mechanism is possibly the leading mechanism of judo-related head injuries. Therefore, head and neck stabilisation during breakfalls can be potentially critical in terms of preventing judo-related head injuries. However, current literature provides conflicting findings regarding the contribution of the isometric neck strength to head and neck stabilisation in response to head perturbation loading (Mihalik, Guskiewicz, Marshall, Greenwald, Blackburn, et al., 2011; Eckner, Oh, Joshi, Richardson, & Ashton-Miller, 2014; Caccese, Buckley, Tierney, Arbogast, Rose, Glutting, et al., 2018; Flao et al., 2018). Therefore, there is limited evidence regarding the direct relationship between neck strength and head and neck stabilisation (Hrysomallis, 2016). In addition, the neck strength increase observed following 8 weeks of neck strength training did not facilitate further enhancement to the head and neck stabilisation response during direct force application (Mansell, Tierney, Sitler, Swanik & Stearne, 2005). Therefore, the neck strength enhancement may not play a critical role in the prevention of judo-related head injuries. On the other hand, there is limited but strong evidence stemming from a prospective study that demonstrates that concussed athletes exhibit lower levels of neck strength in the pre-season examination than non-concussed ones (Collins, Fletcher, Fields, Kluchurosky, Rohrkemper, Comstock, et al., 2014). Hence, and according to these previous findings, it can be suggested that neck strength may predict the risk of concussion in high school athletes. Consequently, the use of isometric neck strength as a screening tool for judo-related injuries requires further evaluation. Due to the lack of such prospective research studies in judo, further studies are needed to elucidate the association between neck strength and the risk of judo-related head injuries.

In addition, our findings demonstrate that the force acting on the whole body COM during breakfalls for *osoto gari* does not correlate with either the peak head linear acceleration or the peak head angular acceleration. In an experiment performing an *osoto gari* throw against an anthropomorphic test device (ATD), Murayama et al. (2014) showed that an additional safety mat significantly reduced the peak head linear acceleration, but not the peak head angular acceleration. Head linear and angular acceleration have represented the head and neck stabilisation response to impact loading, and head angular acceleration is strongly associated with brain injuries (King, Yang, Zhang, Hardy & Viano, 2003; Kleiven, 2013). Therefore, it can be deduced that a reduction in the imposed physical impact during *osoto gari* may not be fully effective in terms of preventing judo-related head injuries.

It is noteworthy that the magnitude of head loading during breakfalls reported in the present study is considerably lower than the concussive magnitude that was previously reported. A previous systematic review and meta-analysis demonstrated that the mean concussive magnitude of head linear and angular acceleration was approximately 99 g and 5777 rad/s², respectively (Brennan, Mitra, Synnot, McKenzie, Willmott, McIntosh, et al., 2016). In contrast, the mean peak head linear and angular acceleration during breakfalls in the present study were 3.2 g (range: 2.4–5 g) and 320 rad/s² (range: 150–400 rad/s²), respectively even in novice judo practitioners with no experience of judo competition. Therefore, as some researchers have stated (Murayama et al., 2014), the present study also confirms that a judoka has a relatively low risk of sustaining head injuries provided there is no direct contact between the head and the judo mat.

Although the main causation of the judo-related injury is believed to be the whiplash-like mechanism, Kamitani et al. suggested that direct head contact may have occurred before the body contact in head injury incidents (Kamitani, Miyazaki, Inaji, & Omiya, 2016). Furthermore, the authors reported that direct head impact with larger head linear and angular acceleration was observed most frequently when using an ATD with short standing height. This result suggests that when judoka are thrown with *osoto gari* by a taller competitor, this may increase the magnitude of direct contact for the head before the body. Therefore, the precise effect of height difference between judoka on the head injury risk needs further discussion.

Our study suffers from several limitations. First, strength measurements were conducted solely in the sagittal plane. Although the sagittal plane motion is the primary movement plane, neck motion during breakfalls for *osoto gari* also occurs in the frontal and horizontal planes (Koshida et al., 2017c). In addition, previous studies have already suggested that head and neck stabilisation may be associated with neuromuscular properties (e.g., rate of force development) rather than with isometric strength (Hrysomallis, 2016; Flao et al., 2018). Therefore, we believe that it is necessary to implement future studies that

will investigate and test neck muscular function more precisely. Finally, we must indicate that one major limitation of this study is that we combined the 3D coordinate data set from the previous research (Koshida et al., 2017c) with a data set from newly recruited participants, to conduct a new analysis. Peduzzi et al. (2014) state that optimal sample size is difficult to calculate but a sample size of at least variable $\times 10$ is necessary for multiple regression analysis (Peduzzi, Concato, Feinstein & Holford, 2014). On the other hand, head injuries in judo often occur immediately after the beginning of a judo career (All Japan Judo Federation, 2020). It would be desirable to have participants who have obtained breakfall skills to some extent but have little experience in competition, to clarify the relationship between head biomechanics and neck function and impact from the judo throw, to develop effective preventive measures for the head injury. However, it is difficult to recruit such participants in the research timeframe. In this study, we took this approach to secure numbers of the data set that satisfy the above conditions, to conduct a valid multiple regression analysis.

CONCLUSIONS

Peak neck strength and the impulsive force acting on the body may not correlate with head and neck stabilisation during breakfalls for *osoto gari*. Our findings suggest that neck strength may not be a useful screening tool for judo-related head injury risk, and a mere reduction in the subsequent impulsive force during breakfalls may not be effective for injury prevention. However, these findings warrant further discussion and investigation by future prospective studies.

ACKNOWLEDGEMENT

The authors would like to thank NAC image technology Inc. for their help during data collection.

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Article history

Received: 05 January 2020

Accepted: 12 May 2022

Judo in Schools in South Africa: A Judoka's Perspective

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Abstract: *Elite sport systems comprise the phases of an athlete's progression from school to international level, as incorporated in the Long-Term Athlete Development (LTAD) model. The model includes elements such as talent identification and development, scientific support, training facilities and coach development. However, varying degrees of implementation are accounted for by contextual differences. Judo is a popular Olympic sport that is practised in schools in South Africa, mostly as an extracurricular activity. The aim of this paper is to describe the perceptions of judoka in South Africa, of their school judo programmes, in the context of an elite judo system. The study utilised a self-structured questionnaire and a purposive random sample of 26 judoka participated in this study. Results indicate that constrained school judo programmes exist in South Africa. The programmes would benefit from a national competition league for schools that establishes partnerships with external service and facility providers, to enhance access to scientific support such as psychology, bio-kinetics, physiotherapy, and training facilities. This would contribute to a comprehensive database, informed by monitoring and evaluation of talented athletes and would embed the programme within the framework of LTAD to establish age and developmentally appropriate participation opportunities. Unique talent identification and development approaches could also create opportunities for strategic competitive advantage. Results reinforce existing literature on long-term scientific approaches to the development of athletes and Judo South Africa's existing LTAD manual, combined with the presence of judo in numerous schools across the country, provide a platform for practical implementation of recommendations in this study.*

Keywords: *school sport, long term athlete development, LTAD, judoka perceptions, judo, sport programmes, South Africa*

Governments increasingly invest significant resources in their elite sport systems with a variety of outcome goals in place. Although the impact of such investments is not always clear, they could add to the achievement of national pride, the creation of a feel-good factor that often contributes to mass participation in sport and ultimately a healthier and happier nation (Grix & Carmichael, 2012). In addition to the potential links with elite systems, sport is a social activity that arguably provides the most significant platform to contribute to nation-building, by uniting wide sections of a population (Riordan, 1999). Sport can also be utilised as a relatively cost-effective tool to support programmes related to education, health and social welfare (Maguire, 2014).

A number of phases of participation in elite sport systems exist that incorporate a programme of athlete development from the lowest to the highest levels of participation. These levels of participation can be explained by an athlete development triangle such as the one proposed by Gulbin, Weissensteiner, Oldenzien and Gagne (2013), with mass participation and school level participation forming the basis thereof. Therefore, school level participation in sport forms part of a feeder system that should increase

the talent pool and, through effective and efficient athlete development pathways, deliver a greater number of high quality champion athletes (Dyer et al., 2017; Goranova & Beyers, 2015). A popular global model that provides a conceptual blueprint for athlete progression from school to elite level is Long-Term Athlete Development (LTAD) (Balyi et al., 2016). Numerous examples exist of nations that have invested successfully in elite sport systems, such as China, the USA, Australia through the Australian Institute of Sport (AIS) and Great Britain (Böhlke & Robinson, 2009). Their systems include contextualised forms of school sport that are dependent on their unique socio-economic, cultural and political circumstances (AIS, n.d.; Chen, 2015; UK Sport, 2015; USOPC, 2020).

The increased recognition for a systematic programme of athlete development from school to elite level emphasises the need for partnerships with the education sector. This should ensure smoother athlete transition to elite status (Radtke & Coalter, 2007). The organisational system relies on input that could include human resources (e.g., athletes, coaches, administrators and technical officials), financial resources (e.g., money and sponsorships) (De Bosscher et al., 2015), material resources (e.g. access to facilities and equipment), goal setting (e.g. performance

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outcomes) and expectations (the outcomes that reaching goals should achieve) (Bevans et al., 2010; Monitoring & Evaluation, 2013). Input for a sport system results in activities (functions carried out that are associated with achieving the goals of an organisational project), outputs (the direct and immediate first level of results associated with a project), outcomes (the second level, medium-term results of a project) and impact (the long-term consequences of a project) (Monitoring & Evaluation, 2013).

The input for elite sport systems focuses on the development of school level athletes by introducing appropriate athlete development programmes including talent identification, regular training, training and qualification of professional coaches, and athlete support including sport sciences, finance, scientific research and sports medicine (Böhlke & Robinson, 2009; De Bosscher et al., 2006). Typically, LTAD plans incorporate age and developmentally appropriate training, focusing on fundamental movement skills from birth to when athletes enter the active for life stage of post-career involvement (CSL, 2015). The links between schools and elite sport systems imply that these factors are under the direct control of governments and national sport federations. Internationally, recognition exists for successful elite sport systems having extensive school sport programmes to varying degrees of implementation, depending on contextual factors, that act as feeders for sports clubs and contribute to delivering high performing athletes in the long-term (Digel, 2005; Gulbin et al., 2013).

A sport that has partnered with governments and schools globally, is judo (IJF, 2019). Judo is also part of the Olympic Movement and has more than 200 international member federations (Ohlenkamp, 2006). In South Africa, judo is practised at schools, in sports clubs, community and recreation centres and at many universities. Some judo instructors in South Africa teach judo in schools as a part of their private business, with the result being that a significant number of judoka at school level practice the sport outside of the national federation's system. Therefore, although Judo South Africa's (JSA) current membership is approximately 3000 members and is practised in seven of the nine provinces in the country (JSA, n.d.), it is estimated that there could be approximately 20,000 active judoka (practitioners of judo).

It is essential that judoka are more effectively recruited and retained within the national federation's system, to provide a sustainable athlete development programme (Gulbin et al., 2013). In line with the Gulbin et al. (2013) triangle of athlete development, an organised school sport programme that includes a systematic LTAD process, is necessary to produce elite athletes (CSI, 2014). Effective implementation of such pyramid models of sport development require attention to athlete recruitment, by incorporating smaller local sports organisations and significant others; retention that focuses on the motivation, socialisation and commitment of athletes; and advancement (establishing vertical and horizontal links to further athlete progression to higher levels of participation) (Green, 2005).

Where there are schools in South Africa that incorporate judo in their sports programme, a gap exists in terms of the understanding of the present school judo programme in the country from the perspective of judoka who have participated in this programme over an extended period of time. This could be the result of the limited formulation and implementation of a systematic, contextualised approach to school judo in the country, leading to the following question in the context of South Africa's elite judo system: What are judokas' perceptions of the school judo programmes that they participate in? Accordingly, the aim of this paper is to describe the perceptions of judoka in South Africa of the school judo programme that they participate in as part of an elite judo system. The following components of a school sports programme as informed by literature and related to the LTAD model, were selected for further exploration: Sport system, training and competition frequency, access to scientific support, training facilities and aspects of coaching and training programmes. These components are unpacked in the results section.

RESEARCH DESIGN

Conceptual framework

The perceptions of judoka were analysed and interpreted from the perspective of the Long-Term Athlete Development (LTAD) model. This model represents a conceptual framework that advocates for the systematic, age and developmentally appropriate development of young athletes to maximise their potential (Spurr, 2014). In terms of the LTAD model, judo is classified as a late specialisation sport that follows seven steps of development from active start to active for life (LTPD, 2010). In this context, the LTAD model serves as a blueprint for the personal and athletic development of judoka as well as emphasising the provision of opportunities for healthy lifelong participation (Judo Canada, 2017). Balyi, Way and Higgs (2013) further emphasise that collaboration with other sectors such as education and health are necessary to facilitate the often-demanding process of athlete development that could result in conflicting demands.

Materials and methods

This paper reports on one section of a broader national study on the development of a contextual school sport programme for judo in South Africa. Although the information is not publicly available, it is estimated from the results that there are at least 100 schools in South Africa that incorporate judo in their school sport or extramural programmes. However, taking the scope of this study into consideration, a more accurate figure would likely be at least 150 schools. This section of the study incorporated a descriptive design, making use of quantitative data, consisting of questionnaires as research instruments. The population consisted of South African judoka, 18 years and older, who appeared on the national ranking list of Judo South Africa. As a result, a purposive random sample was recruited from this population to participate in the study. In total, a representative sample of twenty-six judoka (n=26) who were recruited for the study completed questionnaires.

The content validity of the questionnaire was established by requesting members from the research population who were

not included in the research sample, to provide feedback regarding the content of the questions. Sight and construct validity were established by submitting the questionnaire to a member of STATKON (Statistical Consultation Services) at the University of Johannesburg. Data from the questionnaires was captured and analysed utilising the Statistical Package for Social Sciences (SPSS). Descriptive statistics such as frequencies, percentages, means and medians were used to describe the collective responses of respondents. The results are presented in tables and figures. Finally, reliability of the questionnaire was measured using Cronbach's Alpha. Reliability scores on the respective scales measured between acceptable (0.731) and excellent (0.979) (George & Mallery, 2003). The questionnaire was based on an instrument used to conduct a similar national study on the development of a contextual framework for a Netball South Africa elite sport system (Nolte & Hollander, 2020). Although themes were broadly similar, the questions were adapted to reflect judo as the topic of this study and literature on school sport specifically was used to inform the adaptation of questions to address the purpose of the study.

Ethical clearance for this study was obtained from the Ethics Committee of the Faculty of Health Sciences at the University of Johannesburg with clearance number REC-462-2020. Written permission to have access to the judo fraternity was obtained from the national judo federation, Judo South Africa.

RESULTS

The questionnaire was composed of two sections. Section one recorded biographical information of judoka (research participants). Section two logged the experiences of the judoka in respect of ten elements, including the sport system, training and competition frequency, access to use of scientific support, access to facilities, training programmes, transport, and considerations related to coaching within the respective school judo programmes. Questions in section two required respondents to rate their experiences by indicating the extent to which they agreed with statements on a 4-point Likert scale with the following criteria; don't agree, slightly agree, mostly agree and fully agree.

Biographical Data

Of the twenty-six judoka who completed the questionnaire, nineteen were male and seven female. The mean age of the respondents was 30.12 years with a Standard Deviation of 10.4. Twenty-one (87.5%) of these judoka have competed at national and/or international level over the past two years. This provides a highly knowledgeable and experienced sample of research participants. A total of 12 (48%) respondents indicated that they had been identified as talented judoka during their judo careers, with only 2 (15.4%) indicating that they were identified as such at school level. In addition, 24 judoka (92.3%) were from urban areas, representing two of nine provinces in South Africa.

Sport System

In this section of the questionnaire participants responded to six statements on the relationship between their school judo programme and the overall sport system they participated in (Figure 1). An acceptable Cronbach's Alpha score was recorded for this scale (0.780). The statements related to the extent to which judo was part of the school sport system and competition league, the extent to which the athlete programme provided adequate preparation for competitions, sport performance, and success and focus on competitions at school level. A total of 155 responses were recorded with percentages and numbers indicated in parenthesis: Fully agreed 32 (21%), mostly agreed 33 (21%), slightly agreed 45 (29%), and disagreed 45 (29%). These responses indicated that 65 (42%) relatively positive responses were recorded, of which 32 (49%) fully agreed and 33 (51%) mostly agreed with the statements.

An analysis of the individual statements indicated that 10 (38%) respondents believed that the athlete programme they participated in contributed to their performance at school sport level and 9 (36%) respondents indicated that the athlete programme contributed to their success from school to elite level. In contrast, 18 (69%) respondents indicated that they did not agree with the statement that judo forms part of a national school sport league and 13 (50%) indicated that they disagreed with the statement that judo was part of the school sport system. The results indicated that LTAD programmes designed to ensure success in competitions, from school to elite level, were limited, and that a general perception existed that judo did not form part of a national school sport system.

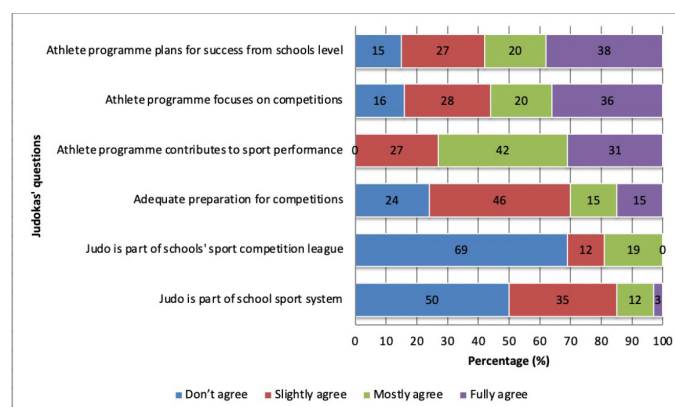


Figure 1: Judoka statements on sport system

Training and Competition Frequency

Training and competition frequency were measured by asking judoka to rate three statements related to the adequacy of school judo training, training camps and competition frequency (Figure II). A good Cronbach's Alpha score was recorded on this scale (0.851). A total of 78 responses were recorded with percentages and numbers of respondents indicated in parentheses: Fully agreed 5 (6%), mostly agreed 24 (31%), slightly agreed 23 (29%), and disagreed 26 (33%). Based on these results, 29 (37%) relatively positive responses were recorded, of which 5 (17%) fully agreed and 24 (83%) mostly agreed with the statements.

Figure II indicates that judoka mostly disagreed that school judo competitions were adequate to enhance their performances, with 9 (35%) participants recording 'don't agree.' With regard to the statement that school judo training camps were adequate to enhance competition performance, 10 (38%) participants disagreed with the statement. A more even distribution existed for responses on school judo training programmes. On the effectiveness of the frequency of school judo training for competition performance, 9 (35%) mostly agreed, 9 (35%) slightly agreed, and 7 (27%) did not agree. Results indicated a clear perception among judoka that the frequency of school judo competitions and training camps were inadequate to enhance competition performance. It is interesting to note that a higher percentage of judoka were more positive regarding the frequency of judo training for competition performance. This could be accounted for by the possibility that some judoka participated in judo training at school and club level.

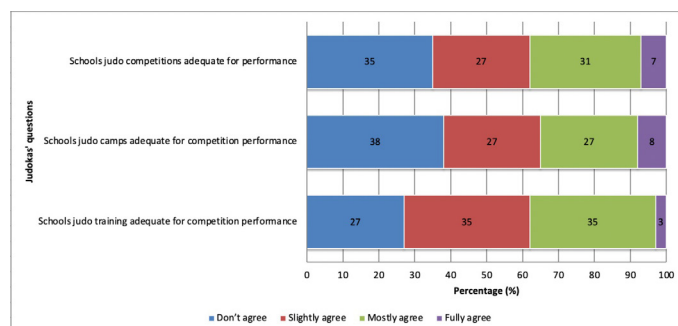


Figure 2: Judoka statements on training and competition frequency in school judo programmes

Access to Scientific Support

Judoka were requested to indicate the extent to which they agreed with seven statements relating to their access to scientific support as it pertained to their school judo programme (Figure III). A good Cronbach's Alpha score was recorded on this scale (0.881). A total of 182 responses were recorded, with percentages and numbers of respondents indicated in parentheses: fully agreed 8 (4%), mostly agreed 20 (11%), slightly agreed 45 (25%), and disagreed 109 (60%). The results showed a small number of relatively positive responses to the statement that addressed access to scientific support (28; 15%). A majority of 154 (85%) respondents only 'slightly agreed' or 'did not agree' to having access to scientific support in their school judo programmes.

When the results of each statement were analysed, it was evident that the majority (15; 58%) of respondents 'did not agree' to having access to bio-kineticists (an allied health practitioner specialising in the rehabilitative modality of exercise), dietary support 17 (65%), physiotherapists 15 (58%), medical doctors 13 (50%), sport scientists 19 (73%), psychology support 15 (58%) and lifestyle support 15 (58%). It is evident from the results that the majority of judoka did not have access to scientific support in their school judo programmes. Scientific support forms an es-

sential part of the LTAD model and the lack of access to this type of support at school level could limit the development of athletes toward the elite level significantly.

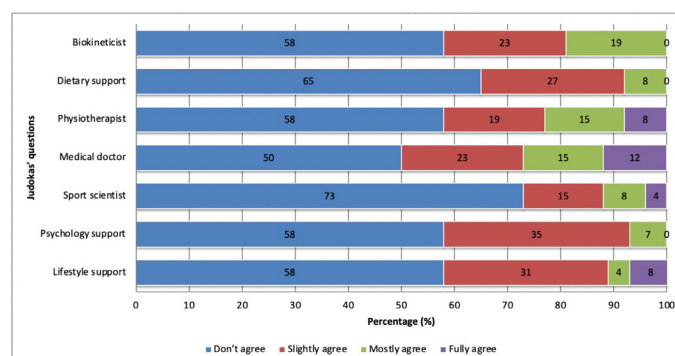


Figure 3: Judoka statements on access to scientific support in school judo programmes

Utilisation of Scientific Support

Judoka were requested to respond to seven questions related to the extent to which they utilised scientific support in their respective school judo programmes (Figure IV). An excellent Cronbach's Alpha score was recorded for this scale (0.907). A total of 174 responses were recorded, with percentages and numbers of respondents indicated in parentheses: Fully agreed 18 (10%); mostly agreed 29 (17%); slightly agreed 29 (17%); and disagreed 98 (56%). In conclusion, 47 (27%) judoka were relatively positive about their use of scientific support as part of the school judo programme, with 18 (38%) respondents fully agreeing and 29 (62%) mostly agreeing to the respective statements.

Analysis of the responses regarding the utilisation of scientific support indicated that the majority of judokas' responses fell in the 'don't agree' category as follows: Bio-kineticists 14 (56%), dietary support 14 (56%), physiotherapists 12 (48%), medical doctors 11 (44%), sport scientists 18 (72%), psychology support 14 (56%) and lifestyle support 15 (63%). Results on this scale were similar to the results on the access to scientific support scale, indicating that a significantly limited number of judoka had access to scientific support, thus negatively influencing the extent to which they made use of it.

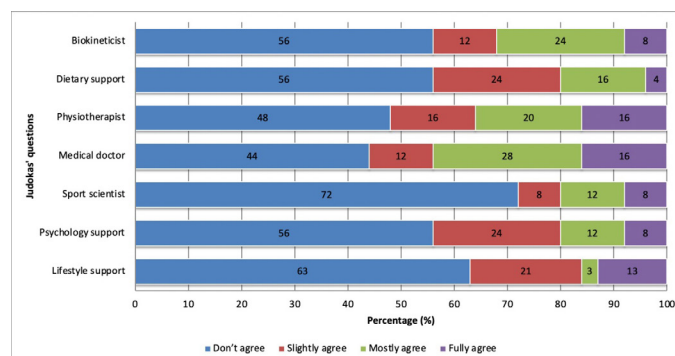


Figure 4: Judoka statements on utilisation of scientific support in school judo programmes

Training Facilities

Judoka were requested to respond to four questions regarding the extent to which they had access to and utilised training facilities in their school judo programmes (Figure V). A good Cronbach's Alpha score was recorded on this scale (0.864). The statements related to strength and conditioning gymnasiums, judo training centres and sport accommodation. A total of 153 responses were recorded with 22 (14%) fully agreeing, 29 (19%) mostly agreeing, 26 (17%) slightly agreeing, and 76 (50%) disagreeing. In total, 51 (33%) relatively positive responses were recorded of which 22 (43%) fully agreed and 29 (57%) mostly agreed with the statements.

An analysis of the individual statements indicated that 15 (58%) judoka did not have access to sport accommodation, 13 (50%) did not have access to a strength and conditioning programme and 10 (38%) did not have access to a judo training centre as part of their school judo programme. The highest proportion of 'fully agreed' responses were recorded for access to a judo training centre, with 6 (23%). It is concerning to note that a high number of judoka did not have access to a judo training centre (venue). These judoka often did judo in school classrooms and temporary training facilities that were used for a variety of other purposes that often took priority over judo. The high percentage on the Access to Sport Accommodation scale could be accounted for by the fact that the schools' respondents attended, either did not have boarding facilities, or they did not require accommodation because they resided in the immediate vicinity of their schools.

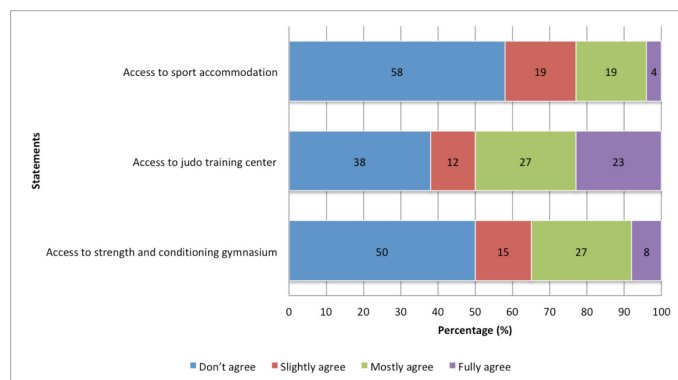


Figure 5: Judoka statements on access to judo training facilities in schools

Training Programme

Judoka were requested to respond to four questions re-Judoka were asked to rate the extent to which training programmes in schools were sufficiently evaluated, monitored, communicated and accessible (Figure VI). An excellent Cronbach's Alpha score was recorded on this scale (0.916). A total of 104 responses were recorded with percentages and numbers of respondents indicated in parentheses: Fully agreed 10 (10%), mostly agreed 19 (18%), slightly agreed 29 (28%) and disagreed 46 (44%). Overall, 29 (28%) participants responded positively, with 10 (34%) fully agreeing and 19 (66%) mostly agreeing with the statements.

The highest scores on the 'don't agree' scale were recorded for evaluation 13 (50%), monitoring 12 (46%), and communication 12 (46%). Numerous judoka also disagreed that they had access to training programmes at school level, with 9 (35%). The results on this scale are particularly concerning when considering the importance of age and developmentally appropriate training programmes as part of the LTAD process.

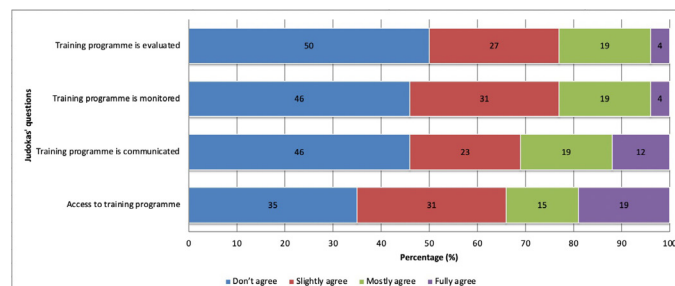


Figure 6: Judoka statements on school judo training programmes

Coaching

On this scale, judoka were asked to rate five statements that related to the coach-athlete relationship and competition performance in their school judo programmes (Figure VII). An excellent Cronbach's Alpha score was recorded on this scale (0.958). A total of 130 responses were recorded with percentages and numbers of respondents indicated in parentheses: Fully agreed 39 (30%), mostly agreed 34 (26%), slightly agreed 21 (16%), and disagreed 36 (28%). In conclusion, 73 (56%) relatively positive responses were recorded, of which 39 (53%) respondents fully agreed and 34 (47%) mostly agreed with the statements.

Based on an individual analysis of the statements, most judoka fully agreed 8 (31%) and mostly agreed 8 (31%) that they had access to their judo coach in their school judo programme. The majority of judoka also fully agreed with the statement that school judo coaches communicated competition performance with, 8 (31%); that their school judo coaches had adequate knowledge to ensure competition performance, with 10 (38%) and that the relationship with their school judo coach stimulated maximum performance, with 9 (35%). In contrast, a majority of 11 (43%) judoka indicated they did not have meetings with their school judo coaches regarding their competition performances.

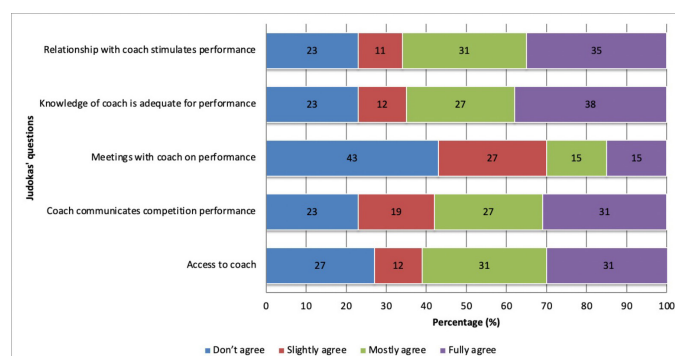


Figure 7: Judoka statements on coach-athlete relationship and competition performance in the school judo programmes

DISCUSSION

This section discusses the results of this study as they pertain to the components that constitute a school sport programme and are positioned within the conceptual framework of the LTAD model. Elements include athlete development (development pathways and sport sciences support), coaches' development (training and qualification of coaches) and physical resources (such as accommodation, strength and conditioning gymnasiums and judo training centres).

Development Pathways

It is evident that the perceived frequency of training and competitions in school judo programmes in South Africa are constrained when compared with the criteria set out in the LTAD model by Balyi et al. (2016). This is particularly relevant in relation to judo training sessions, training camps and competitions. The results reaffirm the fact that judo in South Africa is not incorporated into the national school sport system as is required for a systematic programme of athlete development (Gulbin et al., 2013; Green, 2005). Furthermore, although a national school judo championship exists, South Africa has not incorporated a structured national school competition league. Interestingly, a relatively high proportion of judoka felt that the frequency of judo training, training camps and competitions in their school judo programme was adequate. This could be explained by the fact that Judo South Africa mostly incorporates a club system and school judoka participate in club judo events. At a more individual level of training, many judoka felt that their training and performances were not monitored and evaluated and that communication and access to training programmes was insufficient to create conditions for high level performances. This is especially concerning when considering that successful LTAD plans include systematic monitoring and development to formulate and implement individualised athlete development plans. Most judo coaches in South Africa only offer one judo training session per week at schools. While some of these coaches provide extra training at clubs in the vicinity, others do not, which is a further compounding factor that leads to the limited implementation of training programmes and the associated monitoring and evaluation thereof. Regular appropriate training from a young age is essential as part of a system of athlete development (De Bosscher et al., 2015).

The results indicated significant challenges in the implementation of training programmes that would ensure a sustainable LTAD programme that delivers high performing elite athletes. Taking into consideration the limited preparation of judoka at school level, it is not surprising that there is a high drop-out rate of judoka when they progress to club level (when they should be registering with the national judo federation). Clearly, a nationally coordinated and implemented school judo programme that incorporates a national judo league with regulation of participation opportunities, should enhance the experiences of judoka training at school level. Another significant aspect

of these findings is related to the role of talent identification and development through training programmes. In line with De Bosscher, Bingham, Shibli, Van Bottenburg and De Knop (2008), countries with smaller populations could gain strategic competitive advantage over their larger competitors by focusing on these elements. Although South Africa has a relatively high population, the small population of judoka by comparison, could derive significant benefit from a strategic focus on these aspects. This further emphasises the need for a contextualised approach to the implementation of LTAD at school level in the South African judo environment.

Sport Sciences Support

Judoka reported limited access to scientific support services at school judo level. The services related to bio-kineticists, dietary support, physiotherapists, medical doctors, sport scientists, psychology support and lifestyle support. Similar results were reported regarding the extent to which judoka made use of scientific support services.

Medical doctors, physiotherapists, sport scientists and bio-kineticists relate mainly to injury rehabilitation and fitness training, whilst psychology and lifestyle support form part of a long-term approach focused on ensuring mental health and post-career involvement, in addition to performance-related success. The fact that the majority of judoka indicated that they did not have access to or utilise scientific support services as part of the school judo programme, has potentially negative consequences for the preparation of judoka for higher levels of participation (Balyi et al., 2016; CSI, 2014; CSL, 2015; De Bosscher et al., 2006).

Providing scientific support services as part of an LTAD plan, particularly at school level, should contribute to a supportive environment for the sustainable development of judoka and establishing partnerships with specialist service providers would encourage a more holistic approach of athlete monitoring and evaluation. In turn, a comprehensive data base of talented judoka can be generated. In combination, this could benefit the national federation by increasing the number of judoka that progress to club and higher levels of participation with the necessary physical and mental skills, attributes and qualities that ensure long-term performance success. Higher post-career involvement of judoka in South Africa could also see them taking up positions as technical officials, administrators and coaches, to a greater extent than is the case at present.

Coach Development

In general, judoka were relatively positive about the criteria relating to their coaches at school level, providing an interesting contrast to other scales of measurement in this study. The criteria which yielded the highest 'fully agree' scores were the statements: Relationship with coach stimulates performance; knowledge of the coach was adequate for competition performance; coach communicates competition performance and access to the coach. In

contrast, the majority of respondents indicated that they did not have meetings with their coach to discuss competition performance.

Professional coaches who teach judo at schools in South Africa do this for a living. At least theoretically, this would imply that they should be accessible to discuss performances with their judokas and be present regularly at judo events such as competitions. The limited contact time at school judo level, where professional coaches often offer only one judo lesson per week, could account for the fact that judokas reported that they did not have sufficient opportunities to meet with their coaches to assess their performances. The fact that most judokas reported they had a good relationship with their coaches, and perceived the coach's knowledge as adequate, contributed to enhanced communication, and confirmed the value of the coach-athlete relationship in an LTAD plan (Böhlke & Robinson, 2009).

It should be noted that regular meetings with judoka regarding their performances could further strengthen the coach-athlete relationship and contribute to positive experiences for judoka in school judo programmes. It is essential for the overall effectiveness and functioning of LTAD plans that they be designed and implemented by highly skilled, experienced and knowledgeable coaches.

Physical Resources

A significant number of judoka indicated that they did not have access to sport accommodation and strength and conditioning gymnasiums at school level, although responses regarding access to judo training centres at school level were relatively positive.

The results regarding facilities clearly concurred with the those of scientific support services and training programmes, indicating that the majority of judoka at school level participated in an environment that provided limited physical resources. This falls short of the goals set out in LTAD models. The high proportion of judoka who did not have any access to a judo training centre at their school is of concern and is perpetuated by sharing venues with other school activities that often take priority over judo. Many schools also do not have strength and conditioning gymnasiums on their properties. De Bosscher et al. (2006) highlights the importance of access to training facilities in the process of long-term athlete development. Access to training facilities is an essential requisite in the establishment and implementation of athlete development pathways and by implication in a school judo programme. If strength and conditioning gymnasiums are not available as part of school facilities, it is vital that partnerships are established in local communities in order to address such shortcomings. Such partnerships could be with community and recreation centres or universities.

The LTAD model has provided significant insight into the interpretation and understanding of judoka perspectives

as they relate to school judo programmes in South Africa. At national level, it is of utmost importance that a competition league is developed, for judoka in all schools to participate. This would have the added benefit of contributing to efforts of establishing judo's status as a recognised school sport in the country. Access to resources such as facilities and sport sciences support could be enhanced by this recognition, as well as partnerships with external service providers. Future studies should focus on posing questions related to the transition process from school to club judo and how this impacts on access to resources and the development pathways of athletes.

Limitations of This Study

These results should be understood within the context of a relatively small sample size that largely resides in urban areas and represents only two provinces in South Africa. Additionally, a limited number of female judoka participated in the study. Therefore, caution should be taken when attempting to generalise the findings to the broader population in the country.

CONCLUSION

Results reported in this study largely correspond with those of the broader national study on the development of a contextual school sport programme for judo in South Africa. Judoka in South Africa identified various aspects that require improvement in the school judo programmes that they participate in, to form part of a holistic LTAD model that could lead to elite judo success and post-career involvement in the sport. Development pathways that incorporate training programmes and training and competition frequency, as well as access to and utilisation of scientific support, should take priority when addressing the implementation of these programmes. Interestingly, a positive aspect that emerged from the results was that judoka perceived the coach-athlete relationship as satisfactory in relation to eliciting competition performance, providing feedback and communication surrounding competition performance, having access to the coach, and regarding the coach's knowledge as adequate for stimulating competition performance.

Whilst it is evident that the school judo programme in South Africa is limited in its implementation and impact as part of an elite sport system, judo in South Africa would benefit from establishing a structured national judo competition league for schools. In turn this should contribute to establishing and eventually enhancing the status of judo towards becoming a recognised school sport in the country, by providing vertical and horizontal links for athlete progression. Further to this, a recognised and effectively implemented competition league could also contribute to partnerships with external service and facility providers, resulting in better access to physical resources such as training facilities. It is vital that the formulation and implementation of a national school judo league is embedded within the conceptual framework of LTAD and informed by age and developmentally appropriate considerations. Therefore, such a league should not only create enhanced oppor-

tunities for competition participation, but also training camps supported by scientific support such as psychology, bio-kinetics, physiotherapy and others that would enhance the athlete development process and establish a database through comprehensive monitoring and evaluation of talented athletes throughout their careers. A significant strategic competitive advantage could be derived by focusing on formulating and implementing contextually appropriate talent identification and development as part of the training programmes of athletes from school level.

Although the results of this study confirm the literature that a research-informed, scientific approach to the development of judoka as part of a systematic long-term approach to the development of athletes is necessary, South Africa's context is varying and complex which requires a contextualised approach to implementation. Therefore, this study contributes to the existing body of knowledge in this regard. In addition, the judo specific LTAD manual for South Africa has been available since 2010 and the existing presence of judo in numerous schools across the country already provides a platform for the practical implementation of the recommendations in this study.

ACKNOWLEDGEMENT

At the time of study, both authors were affiliated with the University of Johannesburg (UJ). We would like to thank UJ for their contribution to this study and the opportunities that have been presented as a result.

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Article history

Received: 14 February 2022

Accepted: 29 March 2022

Weight Loss for Judo Competition: Literature Review and Practical Applications

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Abstract: *A large number of judo athletes engage in long-term and rapid weight loss practices. There is evidence to suggest that these practices may induce adverse effects on the physical and mental health of the judoka, but there are conflicting findings regarding the impairment of performance. Further investigation is required to examine whether the 16 h time-period between the weighing and competition is adequate to diminish any negative effects on health and performance. It has been suggested that in the case when the decrease in body weight is less than 5%, restoration of body fluids and muscle glycogen stores may diminish the negative consequences on performance. Considering the possible acute and long-term negative health consequences, rapid and/or excessive weight loss should be discouraged. Considering that athletes are influenced mainly by their coaches for weight loss, education of both coaches and athletes is needed to support the implementation of safe weight loss strategies for judokas.*

Keywords: *combat sports; weight-making; dehydration; performance; recovery; health*

THE OLYMPIC SPORT OF JUDO

Judo is a high-intensity combat sport in which the athletes (judoka) attempt to throw the opponent to the floor on their back or to control them during groundwork combat (Franchini et al., 2007). Success in judo competition can be determined by a number of specific variables (Franchini, 2021) such as physical fitness (Franchini et al., 2011), technical-tactical abilities (Miarka et al., 2016), psychological factors (Uriarte Marcos et al., 2021) and body weight management (Artioli, Gualano et al., 2010; Lakicevic et al., 2020).

In judo, athletes compete in weight categories, i.e. are matched with an opponent of equal body weight (BW) (Franchini et al., 2012; Langan-Evans et al., 2011). Athletes often engage in a process of losing weight to compete in a category that is lower than their normal BW, to possibly gain a competitive advantage against a lighter opponent (Burke et al., 2021; Langan-Evans et al., 2011; Reale et al., 2017b). This process involves various approaches regarding the manipulation of BW before and after the weigh-in, including acute and/or chronically applied strategies (Burke et al., 2021; Reale et al., 2017b).

Many of the previously published reviews involving weight-making strategies and their effects on performance, refer to combat sport athletes in general (Barley et al., 2019; Franchini et al., 2012; Gann et al., 2015; Langan-Evans et al., 2011; Matthews et al., 2019; Pettersson

et al., 2013; Reale et al., 2017a, 2017b, 2018). However, the different rules of each sport (i.e., the weight classification system, the number and duration of the contests in the competition day, the timeframe between weigh-in and competition, the existence of an additional weigh-in) may differentiate the weight loss approaches across sports. Only one recent review has focused on judokas, however, it is limited to reviewing the effects of rapid weight loss (RWL) (Lakicevic et al., 2020).

Therefore, the aim of this article is to specifically focus on judo athletes and review the weight loss practices employed as well as their physiological and psychological consequences and the effects on health, performance and competitive success. Furthermore, some potential recommendations will be provided to help minimize the harmful weight-making consequences and support the implementation of safe weight loss strategies in judokas.

Physiological requirements of judo competition

The duration of a judo contest is 4 minutes of real contest time, or until a judoka obtains a maximum result (ippon) that determines the end of the match. If neither athlete obtains a technical score in the regular time, then the contest can be won during the extra-time period (golden score) (International Judo Federation, 2020). Therefore, a match may last from seconds up to several minutes. An athlete may compete in 1-7 matches on the same competition day from morning to afternoon. Any contestant is entitled to a minimum of 10 minutes rest between contests (International Judo Federation, 2020). The typical time structure of a judo contest is 20–30s of competitive physical

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activity interrupted by pause periods of 7-10s, with the activity-pause ratio normally to be 2:1 or 3:1 (Franchini et al., 2013; Miarka et al., 2012).

Due to difficulties in conducting physiological measurements during real competition, most studies examining the physiological demands of judo competition have been conducted in simulated matches. The heart rate recorded in such studies corresponds to 90% - 99% of maximum heart rate (André et al., 2021; Isacco et al., 2020; Sbriccoli et al., 2007; Stavrinou et al., 2016). The physiological demands of a judo match involve both the aerobic and the anaerobic energy pathways. Energy for the fast, all-out bursts of maximal power, like the scoring actions, during the match is provided mainly by the anaerobic metabolism. The aerobic system contributes to the maintenance of the intermittent work performed during the match and also to the recovery between the short intervals (Franchini et al., 2011, 2013). It has been suggested that judo matches require important anaerobic contribution in the first and increased aerobic contribution in the final minutes of the match (Franchini et al., 2013; Julio et al., 2017). The activation of the glycolytic pathway has been indicated in previous studies with moderate to high lactate concentrations reported following simulated matches (Bonitch-Gónzaga et al., 2012; Stavrinou et al., 2016). Furthermore, probably the time during the pauses is not adequate to allow the resynthesis of the phosphocreatine (PCr) degraded during the activity phases, causing thus an augmentation of the aerobic metabolism contribution during the match (Bogdanis et al., 1996). Interestingly, Julio and colleagues (Julio et al., 2017) estimated the contributions of energy systems in a 4-min simulated match as follows: ATP-PCr = 15%; Glycolytic = 7%; Oxidative = 78%. Even though the evaluated match had some restrictions, the authors suggested that judo matches rely predominantly on the oxidative metabolism. Furthermore, aerobic metabolism is also important for an effective recovery between matches (Franchini et al., 2011). As medal winners in judo may compete in 5-7 contests during a competition day, a full recovery is needed for maximizing performance in the following matches, especially when short intervals are available between contests.

Physiological profiles of judo athletes

From the physiological viewpoint, high levels of aerobic capacity and anaerobic power are important for a successive performance in judo competitions (Franchini et al., 2007, 2011). Data from the available literature show VO_2max values of 44-64 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for male judokas and between 40 and 53 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for female judokas of all levels (Franchini et al., 2011; Torres-Luque et al., 2016). To evaluate the anaerobic profile of judo athletes, upper and lower body Wingate tests have been used in many studies and presented that judo athletes of both sexes show great power and anaerobic capacity, especially when exercise involves the upper body (Franchini et al., 2011).

Other major physical fitness factors of judo performance are maximum isometric and dynamic strength, as well as

muscular endurance (Branco et al., 2018; Franchini et al., 2011). Since judo is a grappling sport, the ability to throw or restrain the opponent by holding the judogi (judo uniform) is highly dependent on strength. Indeed, some previous studies have shown that maximal strength is a discriminatory component between athletes with different competitive level (Branco et al., 2018; Drid et al., 2015). Moreover, judo techniques have to be performed at high speed and against high resistance from the opponent, thus high levels of muscle power are also needed.

Regarding body composition, as judo athletes compete in weight categories, it is desirable to maximize fat-free mass and minimize the fat mass for the same weight and also to achieve a high power-to-weight ratio. Previous studies have shown that male senior judoka have body fat of <10% of BW and 8%–15% in the case of international and national level athletes respectively (Franchini et al., 2011; Torres-Luque et al., 2016). Female senior elite and non-elite judoka have body fat percentage of 15-23% (Franchini et al., 2011; Torres-Luque et al., 2016).

WEIGHT LOSS IN JUDO ATHLETES

In judo, seven weight categories for each sex exist in the senior age group, with the difference between two consecutive weight categories ranging from 6-10 kg in male athletes (<60 kg, 66 kg, 73 kg, 81 kg, 90 kg, 100 kg and >100 kg) and 4-8 kg in female athletes (<48 kg, 52 kg, 57 kg, 63 kg, 70 kg, 78kg and >78 kg).

According to the rules established by the International Judo Federation, the official weigh-in is organized one day before the competition at 18:00 hours. Athletes must be within the weight limits of a category in which they are inscribed and there is no tolerance. Failure to achieve the desired weight status results in withdrawal from the competition. Athletes can stand on the scale only once during the official weigh-in period. It is important to note that for International Judo Federation official events there is another weigh-in taking place on the day of the competition for a number of athletes randomly chosen. This random weigh-in occurs 1 h before the start of the competition and the weight of the athlete cannot be > 5% higher than the official maximum weight limit of the category (International Judo Federation, 2020). Given that the official competition usually starts at 10:00, that means that there are 15-16 hours available for recovery before the random weigh-in or the competition start, respectively (Figure 1).

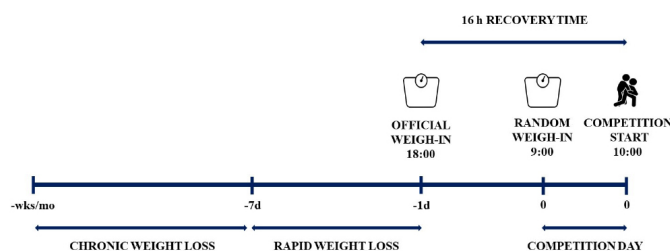


Figure 1. Overview of the timeline of weight loss and recovery for a judo competition

Prevalence and magnitude of weight loss

Frequent use of weight loss strategies is very common in judo athletes. The percentage of judoka losing weight has been reported to be 63% - 89% (excluding heavy weight athletes) (Artioli, Gualano, et al., 2010; Brito et al., 2012; Escobar-Molina et al., 2015; Malliaropoulos et al., 2017). This weight loss behavior has been presented in judokas worldwide, in both sexes (Artioli, Gualano, et al., 2010; Escobar-Molina et al., 2015; Malliaropoulos et al., 2017; Reale et al., 2018), in all age groups (Artioli, Gualano, et al., 2010; Berkovich et al., 2016; Do Nascimento et al., 2020; Escobar-Molina et al., 2015; Kurt et al., 2018) and competitive levels (Berkovich et al., 2016; Brito et al., 2012; Malliaropoulos et al., 2017). The magnitude of weight loss is usually around 2-5% of BW (Artioli, Gualano, et al., 2010; Reale et al., 2018), while higher reductions of 5-10% have also been reported in a considerably high percentage of athletes in the literature (Artioli, Gualano, et al., 2010; Brito et al., 2012; Escobar-Molina et al., 2015). The reported number of times that a judo athlete cuts weight per year varies between studies. It has been reported that most athletes may use weight loss strategies up to 5 times per year to, in preparation for a competition, but a significant percentage reduces their weight for up to 10 times a year or more (Artioli, Gualano, et al., 2010). Judokas report that the weight loss starts approximately 7-14 days before competition (Artioli, Gualano, et al., 2010; Barley, Chapman, & Abbiss, 2018; Berkovich et al., 2016; Brito et al., 2012; Reale et al., 2018), however, the majority of weight loss takes place within the week preceding competition (Berkovich et al., 2016; Brito et al., 2012). Furthermore, studies show that judo athletes are usually unable to maintain their BW following weight loss and regain it in the week following competition (Artioli, Gualano, et al., 2010; Barley, Chapman, & Abbiss, 2018; Reale et al., 2018). Athletes participate in many competitions throughout a season, meaning that they will have to reduce BW again every time. This weight loss, either rapid or gradual, to "make weight" and the subsequent pre-competition weight gain is called "weight" (Artioli et al., 2016; Gann et al., 2015).

WEIGHT LOSS PRACTICES

Long-term weight loss

The long-term BW manipulation includes strategies implemented over several weeks or months to facilitate a modulation of body tissues; reducing fat mass while maintaining or gaining fat-free mass (Burke et al., 2021; Langan-Evans, Reale, et al., 2021). Long-term weight loss may achieve the desired weight loss gradually, eliminating or reducing thus the need for weight loss practices associated with RWL (Gann et al., 2015). This approach may reduce the yo-yo dieting that occurs each season (Manore, 2015).

Indeed, data from case studies of other combat sport athletes show that when scientific and structured long-term approaches are implemented, including gradual dieting and manipulation of training load, a great BW loss is achieved without health and performance implications (Langan-Evans, Germaine, et al., 2021; Morton et al., 2010). To the best of our knowledge, no such study regarding judo athletes has been published.

Rapid weight loss

Rapid weight loss (RWL) (also called acute weight loss) is characterized by the reduction of a significant amount of BW; typically ~2 to 10 % of their BW before every competition, mostly in the 2–3 days prior to weigh-in (Artioli et al., 2016). Other researchers characterize RWL as transitory weight loss of at least 5% of BW in less than a week (Khodaei et al., 2015).

RWL is highly prevalent in judo athletes (Artioli, Gualano, et al., 2010; Berkovich et al., 2016; Malliaropoulos et al., 2017) as in other combat sport competitors (Barley, Chapman, & Abbiss, 2018; Drid et al., 2021; Kirk et al., 2020). Various studies examined whether gender, competition level, weight class or age could affect the prevalence or the applied practices of RWL. In the available literature, most studies reported that gender is not a factor affecting the prevalence of RWL (Artioli, Gualano, et al., 2010; Malliaropoulos et al., 2017; Reale et al., 2018). In contrast, one study (Escobar-Molina et al., 2015) reported that more males used weight loss practices or lost more than 5% of their BW compared to females. Regarding competition level, it is unclear if there are any differences in weight loss prevalence or practices. There is evidence of a trend of increased prevalence of RWL as competitive level increases in males and females, however a statistical significance was found only in males (Malliaropoulos et al., 2017). Also, there is conflicting evidence as to whether competing at a higher level is associated with more aggressive weight loss practices (Artioli, Gualano, et al., 2010; Brito et al., 2012; Reale et al., 2018). It also appears that weight class does not affect the prevalence or practices of RWL for judo athletes (Artioli, Gualano, et al., 2010; Malliaropoulos et al., 2017; Reale et al., 2018). It has also been suggested that judo athletes reduce more weight as they get older (Escobar-Molina et al., 2015).

There is a wide range of RWL strategies commonly utilized by judo athletes that help them lose excess weight fast by reducing total body water, glycogen stores and gastrointestinal tract contents over a period of hours or days (Burke et al., 2021). In general, athletes often use a combination of these practices, with the selection mainly depending on the available time to lose weight and recover and the desired BW loss. However, it is important to note that most studies rely on athletes' self-report, therefore these data may not accurately represent the true prevalence and the applied RWL methods.

The combination of increasing exercise volume and at the same time restricting energy intake aiming to modify energy stores, appears to be the more frequent RWL methods used by judokas (Artioli, Gualano, et al., 2010; Barley, Chapman, & Abbiss, 2018; Berkovich et al., 2016; Brito et al., 2012; Escobar-Molina et al., 2015; Kons et al., 2017; Malliaropoulos et al., 2017; Reale et al., 2018). It has been reported that sometimes judokas use extreme methods of energy intake reduction such as skipping meals and fasting (Artioli, Gualano, et al., 2010; Berkovich et al., 2016; Malliaropoulos et al., 2017; Reale et al., 2018). The increased physical activity, along with the specific reduction of dietary carbohydrate

(CHO) intake induces a decrease in glycogen stores in liver and muscle. Given that glycogen storage is associated with water retention (approximately 3 g per gram of glycogen) (Jeukendrup, 2011), a decrease in glycogen stores results in a significant weight reduction via the loss of glycogen and bound water (Reale et al., 2017b).

The restriction of energy intake may also lead to the manipulation of gastrointestinal tract contents. Beside the reduction in total food mass, the use of a low-fiber diet will likely lower BW as a consequence of reduced gastrointestinal contents and fluid in the intestinal lumen bound to dietary fiber (Reale et al., 2017b), with a minimal effect on acute nutritional status or performance (Reale et al., 2017a). Some more aggressive methods such as the use of laxatives or vomiting have also been reported amongst judoka in a lower frequency (Artoli, Gualano, et al., 2010; Barley, Chapman, & Abbiss, 2018), presumably to facilitate in the expulsion of gastrointestinal tract contents.

Another popular RWL method is body water manipulation through fluid restriction and passive and/or active sweating (Burke et al., 2021). Restricting fluid ingestion has been reported by judokas as one of the most commonly applied RWL method (Artoli, Gualano, et al., 2010; Barley, Chapman, & Abbiss, 2018; Kons et al., 2017; Malliaropoulos et al., 2017; Reale et al., 2018). Passive sweating is a relatively simple method promoting weight loss with the use of thermally stressful conditions like wet or dry saunas, hot baths and sweat suits. A considerable proportion of judoka reported the use of active sweating, mainly through training wearing plastic or rubberized suits and/or training in heated rooms which can be easily incorporated into existing training sessions before weigh-in (Barley, Chapman, & Abbiss, 2018; Brito et al., 2012; Kons et al., 2017; Kurt et al., 2018; Umeda et al., 2004). A smaller number of judoka reported to use diuretics to promote a greater urine loss despite that is prohibited by the World Anti-Doping Agency (Artoli, Gualano, et al., 2010; Brito et al., 2012; Escobar-Molina et al., 2015).

Consequences of weight loss

Research has been conducted to evaluate whether the weight loss procedures may affect physiological, psychological, performance and health parameters as well as competitive success which is the ultimate goal. However, the limited number of available studies focusing on judo athletes and their methodological heterogeneity (e.g., the variety of applied methods to lose BW, the duration and the amount of BW reduction, the athlete level, the available recovery time and the refeed and rehydration opportunities) produces controversial results. Furthermore, it is very important to note that many of the studies which are described below were conducted before the rule change regarding weigh-in. For instance, before 2014 the weigh-in was held in the morning of the competition day having thus only 2-4 h of recovery, in contrast with the new rules where the weigh-in takes place in the afternoon before, giving thus 16 h available recovery. Therefore, the results of these studies must be interpreted with caution as they could be misleading for conclusions.

Physiological consequences of weight loss

Regarding anaerobic performance, no reduction was found in three bouts of a 30-s Wingate test for the upper limbs (Artoli, Iglesias, et al., 2010) or in 30 s and 60 s Wingate tests (Fogelholm et al., 1993), when athletes lost 5% and 6% BW followed by 4 h and 5 h re-fed and rehydrated recovery respectively. In addition, Mendes and colleagues (Mendes et al., 2013) reported that 5% of RWL followed by a 4 h recovery period with ad libitum eating and drinking did not elicit measurable impairments in high-intensity upper-body intermittent performance (8×15 s all-out arm-crank exercise bouts separated by 20 s passive recovery periods) in combat sport athletes, mostly judoka. In contrast, other study reported that maximal anaerobic power was reduced in the high (5.5%) but not in the low (1.3%) weight reduction group (Umeda et al., 2004). Regarding aerobic performance, VO₂peak and peak treadmill-running performance did not change significantly, however, performance at 4-mmol lactate threshold was higher after 5.5% of RWL in combat sport athletes including judokas (Reljic et al., 2016).

Controversial results concerning the effect of weight loss on isometric strength were found. Some studies (Coufalová et al., 2014; Filaire et al., 2001; Morales et al., 2018) reported that isometric strength of upper and lower extremities and trunk traction strength were not affected by weight loss, while others (Clarys et al., 2010; Coufalová et al., 2014; Degoutte et al., 2006; Filaire et al., 2001) reported that isometric arm and trunk strength was reduced, with the athletes in all studies losing ≥3% BW. According to another study, judo athletes with ≥2.7% reduction of total body water may lose ≥2% of forearm maximal strength (Silva et al., 2011). Recently, the effects of judo fights on maximal handgrip strength and upper limb anaerobic capacity of national judo competitors with vs without RWL (3% BW) were examined (Isacco et al., 2020). The results showed that cumulative fights lead to uncoupled responses in physical parameters in judo competitors who underwent RWL vs those who did not.

A lack of changes in a 7-s jumping test, simple or counter-movement jumps were presented in some studies (Filaire et al., 2001; Koral & Dosseville, 2009). Similarly, an interval test consisting out of 5 series of 20 maximal jump squats interspersed with 1 minute rest intervals as a simulation of the exercise pattern of a 5-min judo match to estimate anaerobic endurance was unaffected by the weight reduction (Clarys et al., 2010). In contrast, a decrease in total work output from successive maximal jumps during a 30 s test has been reported (Filaire et al., 2001).

Opposite findings were also found in reaction time where a study showed that it was not impaired (Clarys et al., 2010) and another one found that it was altered (Morales et al., 2018). Only one study has examined the effect of weight loss in balance, which demonstrated that balance is altered when losing >3% BW within the week prior to competition (Morales et al., 2018). Finally, a study evaluated the effect of 10% BW reduction in two weeks on the decision-making performance of judokas and showed no impairment in the experimental group, while the control group improved the decision-making index based on scoring and no-scoring actions (Fortes, Lira, et al., 2017).

Effect of weight loss on performance and competitive success

Very few studies examined the effects of weight loss on judo performance. Most studies utilized laboratory tests for assessing performance, however the use of a judo-specific test like the Special Judo Fitness Test, is more representative of judo performance (Drid et al., 2012). Two studies found decreased performance in this test (lower number of throws and augmented heart rate 1 min following the test) in male judo athletes that lost 10% BW in 2 weeks (Fortes, Costa, et al., 2017) and 4.2% BW in 7 days (Abdelmalek et al., 2015). However, it is important to note that in these studies the athletes were not allowed to refeed and rehydrate *ad libitum* before performing the test. In contrast, no effect on throws or heart rate was found in another study where the judokas that lost 4% BW in 5 days were free to consume food and water after the weigh-in (Lopes-Silva et al., 2014).

In one of the few studies examining the judo performance during combat, RWL of 5% BW did not affect the number of attacks in judo combats in experienced weight-cyclers when the athletes had 4 h to recover allowed to refeed and rehydrate (Artioli, Iglesias, et al., 2010). One study reported that a combination of gradual and RWL by 2-6% in 4 weeks did not affect performance of judo movements over 5 s, while judo movement repetitions over 30 s were decreased (Koral & Dosseville, 2009). On the other hand, an increase in the perceived physical effort (RPE) was found in the weight loss group compared with the weight stable group in the last 2 of 5 simulated fights (Isacco et al., 2020). Recently, a significant increase in heart rate and a decrease in the number of uchikomi (technique training through repeated practice of judo moves) executed from session 1 to 11 was reported, when a concomitant 4-5.5% BW RWL occurred (André et al., 2021).

Competitive success in judo, as stated above, depends on multiple physiological factors including aerobic and anaerobic fitness, strength and power, but also on psychological variables and technical and tactical proficiency. In addition, weight loss practices and individual recovery strategies between weigh-in and competition and between the fights may potentially influence the result. Furthermore, it is relevant to consider that the performance is measured compared to the other athletes in the specific competition rather than an individual's absolute best (Reale et al., 2017b). Considering also the difficulty of performing experimental procedures during real competitions, taken together, the association between weight loss and winning/competitive success is difficult to be established.

It has been suggested that judo athletes that constantly lose weight, are used to losing weight and may thus become resistant to the negative effects of RWL (Artioli, Iglesias, et al., 2010; Isacco et al., 2020). This assumption was questioned by a study which reported that regardless of previous experience in RWL procedures, RWL of $\leq 5\%$ of BW loss with ~ 4 h or more for recover after weigh-in, has no impact on performance (Mendes et al., 2013).

As the purpose of the weight loss is to provide a possible weight advantage against an opponent in the competition, rapid weight gain may enable athletes to enter competition heavier. A recent review showed that by engaging in rapid weight gain, combat sport athletes are able to compete up to three weight categories higher than at the official weigh-in (Matthews et al., 2019). There is conflicting evidence in other combat sports whether the magnitude of rapid weight gain may be an important factor for success (Faro et al., 2021; Kirk et al., 2020; Wroble & Moxley, 1998). Only one study has examined the relationship between post weigh-in weight re-gain and competitive success in judo athletes and showed that medal winners' judo athletes recorded the greatest amount of weight re-gain compared with their less successful counterparts in real life judo competition (Reale et al., 2016).

However, athletes that use rapid weight gain exploiting the rules, undermine the purpose of matching competitors of an equal body mass and could be violating the spirit of the sport (Artioli et al., 2016; Lakicevic, Mani, et al., 2021; Matthews et al., 2019). Furthermore, considering that RWL meets all three of the World Anti-Doping Agency's criteria to ban a method from sport (i.e. potential to enhance sports performance, potential risk to athletes' health and violation of the spirit of sport), it has been suggested that it should be banned from combat sports (Artioli et al., 2016).

Psychological consequences of weight loss

The profile of the mood states (POMS) was frequently used for evaluation of psychological distress in weight reduction studies for judokas. Most studies agree that RWL is associated with changes in mood states such as increased tension, anger and fatigue and reduced vigor (Degoutte et al., 2006; Filaire et al., 2001; Fortes et al., 2018), while an increased depression was also found (Fortes et al., 2018). The same evaluation tool was used in studies utilizing a combination of gradual and RWL. An increase in scores for confusion and tension, and a decrease in vigor, one day before the championship was found in the study of Koral & Dosseville (2009). Decreased vigor and increased fatigue was reported in the over 5% but not in the under 5% weight loss group of university judo players (Hiraoka et al., 2019), whereas increased fatigue and tension and decreased vigor was found for male but not for female judokas (Yoshioka et al., 2006).

The psychological-related states seem to be influenced by age and sex. It has been reported that seniors appear to develop more effective strategies to cope with weight loss compared to cadet and junior judoka (Escobar-Molina et al., 2015). Moreover, cadet and junior females are more likely to suffer from psychological consequences associated to weight loss. On the other hand, not only negative psychological consequences are available in the literature. National judoka among other combat sport athletes reported that practicing weight regulation gives them a mental advantage, mediates a self-image of being "a real athlete" and is also considered mentally important as a part of the pre-competition preparation (Pettersson et al., 2013).

Health consequences of weight loss

Long-term weight loss practices have been proposed as a viable alternative to RWL because of the fewer safety concerns associated with this method (Franchini et al., 2012; Gann et al., 2015). However, on a continuum, low energy intake combined with excessive exercising may lead to prolonged negative energy balance. This accumulated energy deficit drives to a low energy availability, leaving inadequate energy to support recovery and to maintain optimal health and performance (Dipla et al., 2021; Mountjoy et al., 2018). Low energy availability is the underlying cause of a syndrome called Relative Energy Deficiency in Sport (RED-S) that refers to “impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health” (Mountjoy et al., 2018). Due to the long-term dietary and weight loss strategies, combat athletes appear at risk for low energy availability inducing consequences of RED-S including cardiovascular diseases, endocrine disruptions, and impaired mental health (Burke et al., 2018). A medical condition often observed in physically active girls and women is the Female Athlete Triad that involves three components: (1) low energy availability with or without disordered eating, (2) menstrual dysfunction and (3) low bone mineral density (De Souza et al., 2014; Nattiv et al., 2007). Body weight loss practices from combat sport female athletes are related with low energy availability, leading to consequences of Female Athlete Triad (Langan-Evans, Reale, et al., 2021). Interestingly, a recent consensus statement suggests that a higher energy availability state and a smaller energy deficiency may affect reproductive and skeletal health in female compared with male athletes (Nattiv et al., 2021). Regarding female judo athletes, a study showed that 58% presented menstrual disorders, while only 7% of non-athlete females reported oligomenorrhea (Rouveix et al., 2007). However, females are drastically underrepresented in studies examining BW loss interventions across both long-term and acute timeframes (Langan-Evans, Reale, et al., 2021) and thus further studies are needed to examine the effects of weight loss practices particularly in female athletes.

Furthermore, athletes who are constantly dieting or repeatedly gaining and losing weight trying to achieve a low BW, could be at higher risk for eating disorders. Indeed, there is evidence of a significantly higher prevalence of eating disorders in both male and female elite athletes representing weight-class sports than elite athletes representing sports with less focus on weight (Sundgot-Borgen & Garthe, 2011). Similar results were presented regarding national judo athletes, showing that the prevalence of eating disorders is higher among them compared to sedentary participants (Rouveix et al., 2007). Regarding prevalence, a previous study has shown that 18% of male and 30% of female athletes competing in weight sports met the criteria for eating disorders, much higher than the 0.5% and 9% reported for the general population respectively (Sundgot-Borgen & Torstveit, 2004).

Although much less attention has been given to judokas compare with other combat sport athletes regarding the effects of RWL on health, studies have shown that RWL is associated with negative health implications in judokas, including increased injury risk, impaired immune function, hormonal imbalance, decreased bone formation and cardiovascular distress.

Injury rate and inflammation indices in Rapid Weight Loss

RWL of $\geq 5\%$ of a judoka's BW can place the athlete at a higher risk of injury compared with athletes who do not lose weight despite having time to recover during the evening before the competition (Green et al., 2007). Moreover, studies propose that RWL may induce muscle damage (Roklicer et al., 2020; Umeda et al., 2004). Male judokas lost $\sim 5\%$ BW during 3 days of RWL period and concurrent to weight loss, an increase in muscle damage markers (myoglobin, creatine kinase and aldolase) was observed (Roklicer et al., 2020). Similarly, the combination of dietary restriction and intense exercise training for weight reduction before competition, elevated serum creatine kinase concentration, suggesting an impairment of muscular function and an increased susceptibility of muscle tissue to injury (Umeda et al., 2004). The concentration of this enzyme remained elevated for up to 7 days after competition, suggesting that athletes who lose weight before competition may need additional recovery time after competition.

Following 7 days of caloric restriction ($\square 6\text{MJ/day}$), the proinflammatory cytokines TNF- α and IL-6 were significantly higher compared to normal diet in judoka performing the Special Judo Fitness Test (Abdelmalek et al., 2015). Other studies reported that a 20-days weight reduction reduced neutrophil phagocytic activity in female (Suzuki et al., 2003) and male (Kowatari et al., 2001) judokas. Taken together, the results of these studies suggest that the immune system is compromised and hence, resistance to infection is decreased following weight loss. Indeed, recently it was reported that over 5% weight loss among judo athletes before competition caused a drop of immunity demonstrated through reduced salivary secretory immunoglobulin A (SIgA) secretion rate in correlation to the incidence rate of upper respiratory tract infection symptoms, even though a 3-weeks gradual weight loss procedure was utilized (Hiraoka et al., 2019).

Metabolic and hormonal changes in Rapid Weight Loss

The hormonal imbalance induced by RWL was reported in several studies. Decreases in testosterone and triiodothyronine (T3) concentrations following food and fluid restriction have been reported in some studies (Abdelmalek et al., 2015; Degoutte et al., 2006; Reljic et al., 2016). The reduction in these hormones could be possibly related to the impaired erythropoiesis and increased hemolysis found after 5.5% RWL within 5–7 days in combat sport athletes including judokas, causing a significant decrease in hemoglobin mass (Reljic et al., 2016).

Furthermore, restricted feeding may induce hypoglycemia (Artoli, Iglesias, et al., 2010) that causes a decrease in insulin concentration (Degoutte et al., 2006), leading in rise of cortisol and growth hormone levels (Abdelmalek et al., 2015; Degoutte et al., 2006). The increase in growth hormone triggers an increased lipolysis in adipose tissue, also indicated by the triglycerides decrease and the increase in free fatty acids found following weight loss in judoka (Degoutte et al., 2006; Finaud et al., 2006). Beside the mobilization from fat, the need for energy in the absence of carbohydrates (CHO) may activate protein catabolism which is reflected by the elevation of urea, ammonia and uric acid reported in RWL studies in judoka (Degoutte et al., 2006; Isacco et al., 2020). The consequent decrease in fat-free mass has been reported in several studies where judo athletes lose weight acutely through energy restriction and intense exercise training (Artoli, Iglesias, et al., 2010; Coufalová et al., 2014; Degoutte et al., 2006; Isacco et al., 2020). Moreover, it has been suggested that the magnitude of decrease in fat-free mass is related to the degree of energy restriction (Umeda et al., 2004). In addition, a study showed that losing 4% BW negatively affected bone metabolic status, with a net increase in bone resorption relative to formation in elite judokas (Proureau et al., 2006).

All these alterations in hormonal and biochemistry parameters constitute a significant health risk for the adolescent athletes who engage in weight loss procedures. Adolescent judo athletes are also utilizing RWL practices (Berkovich et al., 2016; Boisseau et al., 2005; Do Nascimento et al., 2020), with studies reporting that judokas begin to cut weight very early, generally before the age of 15 years (Artoli, Gualano, et al., 2010; Berkovich et al., 2016). Studies from wrestling showed that undernutrition may lead to hypothalamic-pituitary-gonadal and growth hormone–insulin-like growth factor-I axes impairment (Roemmich & Sinning, 1997) and that an association of weight reduction with reduced testosterone concentrations may exist (Karila et al., 2008). These studies suggest that the growth of adolescent athletes can be affected by weight loss and thus uncontrolled weight reduction is not recommended to growing adolescents.

Dehydration in Rapid Weight Loss

Dehydration, which is widely used by judokas for making weight may have consequences in their health. However, the effects of executing dehydration methods by judoka are scarce. Physiologically, as plasma water decreases, blood viscosity increases, with a reduction in peripheral blood flow and cardiac output leading to cardiovascular strain (James et al., 2019; Trangmar & González-Alonso, 2019). Furthermore, it has been reported that even mild dehydration (2% of BW) may impair endothelial function (Arnaoutis et al., 2017). A larger body water loss, as it often occurs in RWL, may potentially lead to a greater effect on the cardiovascular system.

Increased heat strain and impaired thermoregulation is another issue related with dehydration. As hypovolemia develops, there is less blood flow to the skin and the ability of the body to remove excess heat from the working muscles is impaired. This certainly adds to the cardiovascular strain and related risks. Furthermore, if dehydration is ac-

companied by exercise, core, muscle and skin temperature rise, blood brain barrier can also be affected, and all combined may potentially lead to heat stroke (Akerman et al., 2016). Furthermore, hypovolemia due to hypohydration, in combination with heavy exercise, can increase the risk for acute kidney injury (Juett et al., 2021; Lakicevic, Paoli, et al., 2021). A significant elevation of serum creatinine following 7 days of RWL in elite judokas was reported, suggesting possible kidney stress (Drid et al., 2019). Recently, it was shown that following 15h of recovery between official weigh-in and competition judoka were still in dehydrated state, being at risk of impaired health status and performance (Ceylan & Balci, 2021).

An interesting point to examine is whether these negative health effects are transient and reversible after the weight gain. In addition, it is still unknown whether these acute effects could lead to long-term consequences. However, very few studies have examined health impairment following weigh-in in judokas. With subsequent weight regain it seems that the hormone imbalance can be reversed (Reljic et al., 2016), while a decrease in bone resorption, favoring bone formation instead of bone loss, was also found (Proureau et al., 2006). In contrast, hemoglobin mass remained at a lower level after a post-competition period compared with the baseline values (Reljic et al., 2016). Nevertheless, the long-term health effects of weight loss, especially RWL, require further research.

Furthermore, the long-term effects of multiple repeated cycles of weight loss and gain throughout the season (weight cycling) are less clear, especially with respect to post-athletic career health (Lakicevic et al., 2021). Even though studies are scarce and firm conclusions remain to be drawn, it has been suggested that weight cycling may induce chronic health consequences such as increased risk for developing diabetes, obesity and cardiometabolic diseases in the future (Miles-Chan & Isacco, 2021; Saarni et al., 2006; Zou et al., 2021).

POTENTIAL MECHANISMS UNDERLYING THE PERFORMANCE IMPAIRMENT FROM WEIGHT LOSS

As mentioned above, energy restricted diet combined with increased exercise is frequently utilized for RWL in order to deplete glycogen stores. In wrestling, following a loss of 5% BW in 3 days, a 54% decrease in intramuscular glycogen concentration was found, while the concentration was repleted to 83% of baseline levels after 17 h of recovery (Tarnopolsky et al., 1996). If a more severe depletion occurs, then the 16 h available recovery of the judokas will not be adequate for a large restoration of glycogen stores. Glycogen depletion decreases substrate availability for glycolysis compromising the rate of ATP regeneration. This reduced CHO utilization promotes a greater utilization of fats for fuel, leading thereby to lower peak lactate concentration and reduced peak respiratory exchange ratio during maxi-

mal exercise (Reljic et al., 2016). Moreover, there is a close relationship between muscle glycogen content and fatigue resistance, as intramyofibrillar glycogen is of key importance for Na, K-ATPase activity and sarcoplasmic reticulum Ca²⁺ release and thereby affecting muscle contractility and fatigability (Ørtenblad et al., 2013). Practically, the suboptimal glycogen levels in a judo competition will possibly affect performance during longer lasting intensive matches or when the athletes have to compete in multiple matches within a competition day (Reljic et al., 2016).

RWL the hours preceding weigh-in is mainly due to losses of water via the various methods outlined in this review. Dehydration can be blamed for a number of ill effects, both physiological, mental or psychological that can lead to diminished performance. Reduction of water leads to hypovolemia, which can lead to elevated heart rate in order to maintain oxygen delivery to the regional tissues and organs (Trangmar & González-Alonso, 2019), and even a mild dehydration may increase resting heart rate by ~10 beats·min⁻¹ (Savvides et al., 2020). This altered cardiovascular function may negatively affect aerobic endurance when ≥2% BW dehydration occurs (James et al., 2019). Furthermore hypohydration also limits anaerobic performance, strength, power and high-intensity endurance (Judelson et al., 2007; Kraft et al., 2012), which is confirmed from studies with combat sport athletes (Barley, Iredale, et al., 2018; Pallarés et al., 2016). The mechanisms explaining these associations are not clear (Judelson et al., 2007), however the impaired neuromuscular function is appealing possible. Dehydration associated alterations in neuromuscular performance such as muscle contraction velocity have been reported (Pallarés et al., 2016), even though others failed to find any neuromuscular impairments (Barley, Chapman, Blazeovich, et al., 2018). In judo, where a multitude of abilities are required, dehydration is bound to have a negative effect on the athletes' physiology and performance.

Recently it has been suggested that dehydration may exacerbate exercise-induced muscle damage and prolong recovery (King, M.A. & Baker, 2020). Therefore, when the judoka are cutting weight and exercising in a dehydrated state, it is possible that the muscles cannot work or recover optimally and there may be an increased risk of muscle damage in the most important week leading to a major competition. In addition, changes in hydration status and electrolyte balance may cause exercise-associated muscle cramps (Maughan & Shirreffs, 2019). The electrolyte imbalance due to dehydration may also affect muscle contractility as previously stated.

In addition, dehydration may impact performance though increased mental fatigue. Even mild dehydration (2% BW) has been shown to have a negative effect on subjective feelings, as it can increase the feelings of fatigue and headache, and reduce the feelings of alertness and ability to concentrate (Aphamis et al., 2019; Savvides et al., 2020; Shirreffs et al., 2004), irrespectively of season and environmental temperature (Stavrinou et al., 2020). Furthermore, these physiological and perceptual responses are related with increased

rating of perceived exertion (RPE), thereby compromising performance (James et al., 2019).

Lastly, moving to a more practical approach, the entire procedure of making weight by energy restriction, increased exercise and dehydration can affect the quality and quantity of training in the days leading to the competition. In the days preceding a major competition, athletes should follow a "taper" periodization in order to achieve high performance and recover from the fatigue associate with the heavy preparation period. During taper, it is widely accepted that training intensity must remain high, close to the competition level, whilst frequency and most importantly volume should decrease (Mujika, 2010). When judoka are losing weight, they usually engage in low-intensity, high-volume exercise, which by definition contradicts taper, and adds more burden to their bodies, the days prior to the major competition. Still, it has yet to be investigated at what degree this disruption of the tapering process by added training volume affects competition performance.

POST WEIGH-IN RECOVERY PERIOD

Under the current rules of International Judo Federation, a period of 16 h after weigh-in and prior to the start of competition is available during which ad libitum food and fluid consumption is allowed to the competitors. Therefore, a full advantage of this time period must be taken in order to regain BW and to reverse any negative effects deriving from weight loss. As judo is a grappling combat sport, unlike striking sports, achieving a greater BW at the competition time may benefit the athlete. However, in case the athlete is selected for the random weigh-in occurring 1 h before the start of the competition, BW cannot be >5% of the weight limit. There are two major considerations for this recovery period: restoration of CHO availability and rehydration (Burke et al., 2021).

A CHO recovery plan is important during the post weigh-in period to restore liver and muscle glycogen. Even though the 16 h recovery period is probably adequate time to largely restore glycogen when stores are not depleted (Tarnopolsky et al., 1996), aggressive restoration may be needed especially when severe restricted CHO feeding along with intense exercise was used as a practice to lose weight driving to glycogen depletion. Following the weigh-in, immediate provision of CHO is important to initiate effective refueling. It has been suggested that on the early (0–4 h) phase of recovery muscle glycogen synthesis rate is higher (Burke et al., 2017) and it may be enhanced by a higher rate of CHO intake (~1–1.2 g·kg BW⁻¹·h⁻¹), especially when consumed in frequent small feedings (Alghannam et al., 2018; Burke et al., 2017; Kerkick et al., 2017). CHO-rich foods and snacks with a moderate-to-high glycemic index should be chosen as may induce greater muscle glycogen storage (Burke et al., 2017; Wee et al., 2005). Adequate energy availability is required to optimize glycogen storage from a given amount of CHO (Burke et al., 2021). The co-ingestion of protein with CHO has proven beneficial in the context of glycogen resyn-

thesis when CHO intake is suboptimal, especially during the first hours of recovery (Alghannam et al., 2018; Jentjens et al., 2001). An intake of at least $0.3\text{--}0.4\text{ g}\cdot\text{kg BW}^{-1}\cdot\text{h}^{-1}$ (or $\sim 20\text{--}25\text{ g}$) of high-quality protein may be required to achieve this effect while also meeting goals for postexercise muscle protein synthesis and enhanced fluid retention for rehydration (Alghannam et al., 2018; Burke et al., 2021; Evans et al., 2017). Furthermore, when a large amount of CHO is consumed ($>60\text{ g}\cdot\text{h}^{-1}$), it has been suggested that the ingestion of a mix of multiple transportable CHOs, e.g., glucose:fructose should be preferred as it increases gastric emptying and fluid delivery compared to glucose only (Jeukendrup, 2017; Jeukendrup & Moseley, 2010).

For a complete restoration of fluid balance, a greater volume of fluid compared with that lost, must be consumed during the recovery period (Burke et al., 2021; Evans et al., 2017). Gastric emptying of liquids is influenced primarily by the volume and energy density of fluids in the stomach (Maughan & Leiper, 1999). Therefore, an initial large fluid bolus (e.g., $10\text{ mL}\cdot\text{kg}^{-1}$) immediately following weigh-in should be consumed by the judokas, with additional boluses at regular intervals to maintain increased gastric volume (Burke et al., 2021; Reale et al., 2017a). To achieve effective restoration of body water and to retain ingested water, electrolytes must also be replaced (Evans et al., 2017). If passive and/or active sweating was used as a RWL method, replacement of the electrolytes lost by sweat (such as sodium and chloride) is essential to allow restoration of plasma osmolality and volume (Reale et al., 2017a). Consuming electrolyte-containing drinks such as oral rehydration solutions or ~ 50 to 60 mmol sodium and/or consuming fluids salty foods, are suggested solutions (Burke et al., 2021). If only fluid restriction was applied to lose weight, then athletes might be hypohydrated, but not electrolyte depleted (James & Shirreffs, 2013). Therefore, in that case, an aggressive replacement of electrolytes is not required (Reale et al., 2017a).

In the post weigh-in period it is important to manage gastrointestinal distress often reported by athletes (Reale et al., 2017a). When athletes are restricting CHO to lose weight, the reduced daily CHO load will likely reduce the capacity to absorb CHO, while the abrupt high CHO intake will likely cause gastrointestinal problems (Jeukendrup, 2017). To offset any potential gastrointestinal issues associated with the consumption of high amounts of CHO required from solid foods, a mixture of fluid and solid foods is recommended. The use of multiple transportable CHO, to prevent these issues has also been proposed (Jeukendrup, 2017). Solid food low in fiber and fat will also lessen potential gastrointestinal stress (Reale et al., 2017a). Moreover, from a practical perspective, it is difficult to have an appropriate meal readily available immediately following weigh-in. Therefore, the use of CHO-containing fluids may be more preferable for immediate ingestion when compared to solid foods that can simultaneously contribute to rehydration in conjunction with exogenous CHO supply, reducing any gut discomfort. Generally, individual well-practiced routines should be applied, in order to maximize recovery and performance and minimize gut discomfort. However, there is a paucity of research investigating different refeeding and rehydrating strategies following weight loss in combat sports and especially in judo.

Furthermore, it should be mentioned here that judoka may also take part in the team competition that takes place on the last day of the event, having thus 1-7 days between the two competitions (depending on the event and the weight category of the athlete). There is a 2 kg tolerance in the weigh-in of team competition for athletes who competed in the preceding individual competition (International Judo Federation, 2020). Therefore, regaining weight must be controlled accordingly.

CONCLUSIONS AND PRACTICAL APPLICATIONS

The great prevalence of reported weight loss indicates the widespread weight-cutting culture that exists amongst judoka. Practice of weight regulation is considered by the athletes as a physical and mental advantage relative to the opponent. Thus, considering that weight loss is part of the sport's culture, it is important to identify practices that may reduce any negative consequences on the athlete's health and performance.

Throughout a season, judo athletes may participate in several competitions requiring weight loss, and therefore the frequent great weight fluctuations to achieve the desired weight can be detrimental to health and performance. Thus, the athletes should adopt a more gradual approach to losing weight, manipulating BW across longer periods, while minimizing the amount of weight that needs to be lost for competition with RWL practices.

For an appropriate long-term weight loss a body composition assessment is necessary to establish whether an individual can feasibly and reasonably achieve a prescribed BW through dietary and training intervention, without compromising either health and/or performance (Langan-Evans, Reale, et al., 2021; Sundgot-Borgen et al., 2013). A body fat cut-off value of 5% for men and 12% for women has been proposed as a raising alarm for negative health effects (Sundgot-Borgen et al., 2013). However, individual evaluation should be undertaken as some researchers suggest that RED-S consequences may occur in individuals with body fat higher than these limits (Langan-Evans, Reale, et al., 2021). The athlete should consume sufficient energy and aim for a gradual weight loss corresponding to $0.5\text{--}1.0\text{ kg}\cdot\text{wk}^{-1}$ BW (Franchini et al., 2012; Langan-Evans, Reale, et al., 2021; Sundgot-Borgen & Garthe, 2011). To maintain lean mass during phases of energy deficits, increased protein intake may be needed (Mettler et al., 2010). Ultimately, as extreme continuous dieting and low energy availability may adversely affect health and performance (Sundgot-Borgen & Garthe, 2011), individual long-term nutrition and training plans are needed for the judoka.

From a practical perspective, even though RWL is not recommended, it has been suggested that a judoka should maintain BW $\sim 5\%$ above weight category one week from competition and then utilize acute weight manipulation to

lose it (Reale et al., 2017a). However, it has also been proposed that athletes with frequent competitions during the season should be encouraged to be $\sim \leq 3\%$ above competition weight and to lose no more than 2% of BW in RWL (Sundgot-Borgen & Garthe, 2011).

In any case, before a judoka engages in RWL practices they should be in a fully hydrated, well-nourished state, offering plenty of opportunity for meaningful manipulation of gut and energy stores content and body water (Reale et al., 2017a). The weight loss plan should be tested in non-important competition and should not be attempted for the first time before a major competition. Although these recommendations apply to most athletes, individualized long-term and rapid weight loss plans should be designed in cooperation with a health

professional. It is very important for the athlete to have full awareness of the negative consequences of each method, knowledge of the banned methods and then to consciously decide the optimal weight loss strategy. A summary of the practical applications is presented in Table 1.

It is alarming that judoka lack knowledge about the effects of RWL (Malliaropoulos et al., 2017). Studies agree that the most influential person in leading athletes on the weight management behaviors is the judo coach (sensei) (Artioli, Gualano, et al., 2010; Berkovich et al., 2016; Kons et al., 2017; Reale et al., 2018). Therefore, beyond athletes, coaches and all health care professionals that work with judoka should be educated on all aspects of weight regulation, so as to develop a culture that promotes safe weight loss practices.

Table 1. Practical applications on rapid weightloss, rapid weight gain and education/planning for judoka

	PRACTICAL APPLICATIONS	REFERENCES
RAPID WEIGHT LOSS	Excessive weight loss ($>5\%$ of body weight) and/or rapid weight loss (within 7 days) should be discouraged due to possible acute and long-term negative health consequences	Franchini et al., 2012; Hiraoka et al., 2019; Khodaei et al., 2015
	If rapid weight loss is considered necessary, judoka should be in a fully hydrated, well-nourished state before applying this strategy	Reale et al., 2017
	In this case, judoka should aim to maximize body fat loss and minimize muscle loss	Franchini et al., 2012
	Increased protein intake may be needed during phases of energy deficits to maintain muscle mass	Langan-Evans et al., 2011; Mettler et al., 2010
	Rapid weight loss in children and adolescents should be avoided	Karila et al., 2008; Lakicevic et al., 2022; Roemmich & Sinning, 1997
RAPID WEIGHT GAIN	Nutritional recovery following weigh-in should be planned comprehensively to optimize judoka's health and performance recovery	Burke et al., 2021; Reale et al., 2017
	Restoring body fluids and energy stores and managing gastrointestinal distress during the post weigh-in period is essential	Burke et al., 2021; Gann et al., 2015; Reale et al., 2017
EDUCATION / PLANNING	Determine judoka's optimal weight category based on body composition evaluation. If the prescribed body weight can't be achieved feasibly and safely compromising health and/or performance change weight category	Langan-Evans et al., 2021; Sundgot-Borgen et al., 2013
	If a weight loss plan is applied, a combination of long-term (<1 kg / week) and rapid ($<5\%$ of body weight) weight loss approaches is preferred to solely using rapid weight loss	Gann et al., 2015; Reale et al., 2017
	Individualized weight loss plans should be designed in cooperation with a health professional and tested firstly in non-important competition	Burke et al., 2021; Khodaei et al., 2015; Reale et al., 2017
	Support adequate energy availability, maintain nutrient status and monitor body weight throughout the season avoiding large fluctuations	Sundgot-Borgen et al., 2013; Yang et al., 2017
	Judoka should have full awareness of safety and health risks regarding weight loss	Malliaropoulos et al., 2017; Sundgot-Borgen & Garthe, 2011
	Developing judo-specific educational programs for athletes and coaches are needed to develop a culture that promotes safe weight loss practices	Franchini et al., 2012; Malliaropoulos et al., 2017; Sundgot-Borgen et al., 2013

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Article history

Received: 06 August 2021

Accepted: 02 March 2022

Physiological Studies on Fainting due to *Shime Waza* (Choking)

A Review of the Literature on Human Experiments

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Abstract: *Judo is unique among the Olympic sports because shime-waza (choking) is allowed to subdue an opponent in competition. However, safety of shime waza has been discussed for over the last half century. Published physiological studies on human experiments of strangulation or shime-waza were reviewed to investigate the safety and mechanism of fainting due to shime-waza.*

The first human experiment of acute arrest of cerebral circulation was performed in 1943 to investigate the physiological changes during fainting. An average time from cervical compression to loss of consciousness was 6.8 seconds and that from unconsciousness to revival was 4 – 8 seconds. Physiological studies on fainting due to shime-waza have been reported since 1950 by Japanese sports scientists followed by western doctors. Kata juji jime (half cross strangle) was mainly used for black belt judoka. It took about 6 – 10 seconds to fall unconscious and 7 – 12 seconds to revive from unconsciousness. Many subjects developed anoxic convulsion after fainting. As there were no significant changes in heart rate and blood pressure during the experiment, the most important mechanism causing unconsciousness was suggested to be brain ischemia due to decreased cerebral blood flow by carotid artery compression and carotid sinus reflex (CSR) contributes little to the response to shime-waza.

Human experiments of shime waza have not developed any dangerous effect. The cause of fainting was not CSR but brain hypoxia due to decreased cerebral blood flow by carotid artery compression.

Keywords: *judo; shime waza; choking; fainting; cerebral blood flow; human experiment*

Judo is unique among the Olympic sports because International Judo Federation (IJF) allows strangulation or *shime waza* to subdue an opponent in competition. Safety of fainting due to *shime waza* in judo practice and competition has been an important issue that needs to be discussed, and a new rule for cadet athletes was established and described in the Sports and Organization Rules (SOR): “If a cadet loses consciousness during *shime waza* they are no longer able to continue in the competition” (IJF, 2017).

Physiological changes of brain function after acute obstruction of the cerebral blood flow have been studied not only in animal models but also in humans. The authors reviewed the literatures of human experiments on unconsciousness due to acute occlusion of the cerebral blood flow and discuss about safety and pathogenesis of unconsciousness due to *shime waza*. In addition, the implications for the scientific and ethical assessment of the human experiments of strangulation is described (Kabat, Denis, & Baker, 1941; Tezuka, 1978).

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MATERIALS AND METHODS

PubMed was searched using a set of terms: judo, choking, strangulation, fainting, unconsciousness, brain ischemia, physiology to extract literatures from January 1940 to June 2021. In addition, related articles were extracted from the Japanese-English parallel journal, “Bulletin of the Association for Scientific Studies in Judo, Kodokan from 1958, Vol 1 to 2021, Vol 18”. Furthermore, old Japanese papers reporting about fainting by *shime waza* were investigated in the Kodokan Library.

First, an old human experiment of acute occlusion of cerebral circulation is presented. American basic scientists presented physiological changes after blocking the cervical vessels to create an unconsciousness state. In the second step, Japanese human experiments of *shime waza* in judo are presented which is followed by modern physiological studies on fainting due to *shime waza* mainly by western doctors.

HUMAN EXPERIMENTS OF ACUTE OCCLUSION OF CEREBRAL CIRCULATION

Rossen, et al. (1943) reported a human experiment named the Red Wing Study to create an unconsciousness state by blocking the neck vessels using their newly developed device. More than half-decade later, Smith, et al. (2011) discovered a large part of the disappeared records from the Red Wing Study and published a revisited paper. Those human experiments are very important issues to understand the safety and physiological changes induced by *shime waza*. The reality and challenges of the Red Wing Study are shown below.

Human subjects and methods

To study the effect of acute cerebral anoxia in human, the Kabat-Rosen-Anderson Apparatus (KRA Cuff) was devised for producing arrest of cerebral circulation by means of a cervical pressure cuff held down to the lower third of the neck. The pressure in the cuff rises to 600 mmHg within one-eighth seconds before the next heart-beat to prevent engorgement. This procedure completed occlusion of the common carotid artery and ascending branches of the subclavian artery with exception of the vertebral artery without affecting the respiratory tract (Figure 1). The venous return from the brain through the internal and external jugular veins and the cervicalis profunda vein are occluded without engorgement of the cerebral vessels. Then acute anoxia is induced in the human brain without affecting respiration. Deflation of the cuff can be accomplished simultaneously with loss of consciousness either by the subject or the physician.

Figure 1

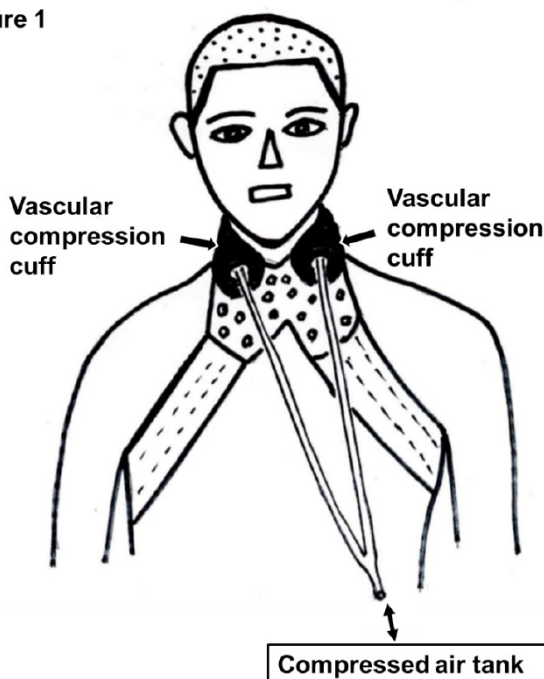


Figure 1. The Kabat-Rosen-Anderson (KRA) Cuff (the cuff is connected to a compressed air tank by 2 tubes - arrows) judo programmes

They performed their human experiments on 137 subjects consisting of 11 schizophrenic patients and 126 normal young males. The latter included 44 inmates between 17 and 31 years of age at the Minnesota State Prison and 82 offenders between 17 and 25 years of age at the Minnesota St. Cloud Reformatory. Arrest time of cerebral circulation for normal subjects was less than 10 seconds and schizophrenic patients as long as 100 seconds for another purpose of this study. The subjects appeared to be well tolerated and followed by rapid and uneventful recovery. Furthermore, the procedure was applied repeatedly to the same subjects with no injurious effects (Rosen, Kabat, & Anderson, 1943; Smith, Clayton, & Robertson, 2011).

RESULTS

Clinical effects of acute arrest of cerebral circulation in normal subjects

The characteristic reactions resulting from acute arrest of cerebral circulation were fixation of the eyeballs, blurring of vision, constriction of the visual fields, loss of consciousness and anoxic convulsions without any danger. After 5 to 6 seconds of acute arrest of cerebral circulation, the eyes fixed suddenly in the midline and the subject was incapable of moving the eyes, although he was still conscious (Figure 2a). Loss of consciousness occurred 0.5 - 1 second after fixation of the eyes.

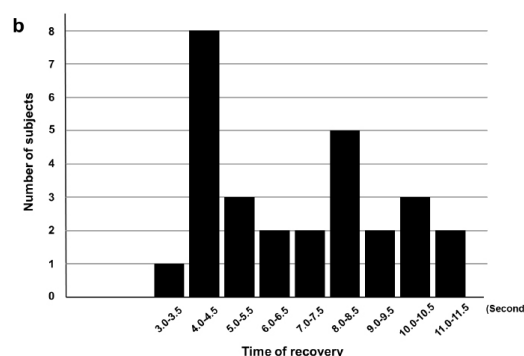
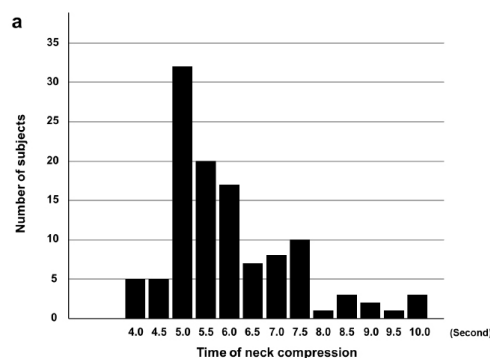


Figure 2a. Distribution of time to fixation of the eyeballs during acute arrest of cerebral circulation in 111 normal young men

Figure 2b. Distribution of time to recovery following acute arrest of cerebral circulation in 28 normal young men (the graph shows average values on repeated tests)

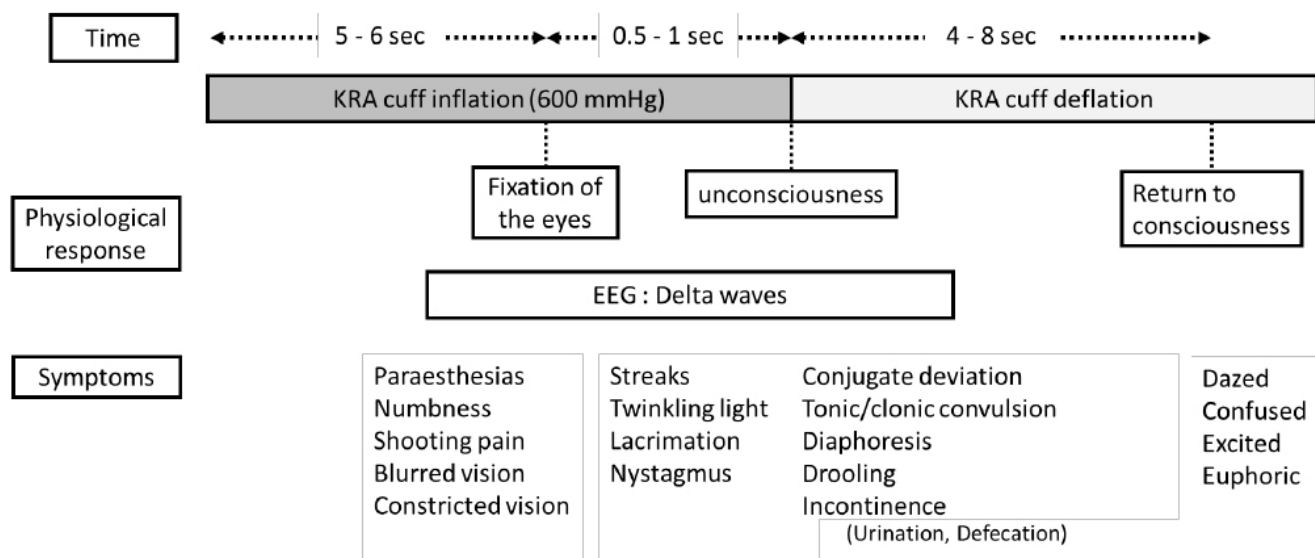


Figure 3. Physiological response to acute arrest of cerebral circulation in human (various symptoms are noted before and after falling unconscious)

About 0.5 seconds after fixation of the eyes in the midline, the eyeballs suddenly turned upward, the reaction coinciding with loss of consciousness and immediately preceding the anoxic convulsions. A generalized tonic and clonic convulsion occurred immediately after release of the KRA cuff and rarely continued more than 6 to 8 seconds, and the subject usually remained unconscious throughout the seizure. Approximately half of the subjects reported paraesthesias: numbness, tingling and shooting pain during arrest of blood flow in the brain which appeared before loss of consciousness and rapidly disappeared after restoration of blood flow. Within 1 second after fixation of the eyes, the subject usually lost consciousness. A variety of mental symptoms, i.e., confusion and excitement were temporarily observed while the subjects recover consciousness. The distribution curve of recovery time for 28 normal subjects is shown in Figure 2b. Most of the subjects revived at 4.0 – 8.0 seconds after release of the cuff. There was no significant correlation between time of recovery and duration of arrest of cerebral circulation.

The sudden appearance of large slow waves (delta wave) was observed in electroencephalogram (EEG) about 1 second before fixation of the eyes which followed by loss of consciousness (Figure 3). No increase in frequency was noted. Increased frequency of brain waves in case of carotid sinus syncope was not a major factor in this type of fainting due to acute arrest of cerebral circulation. All subjects could stand, walk out of the room, and go about their work within 1 or 2 minutes after the procedure, and no later effects were observed.

Prolonged arrest of cerebral circulation in schizophrenic patients

Cerebral circulation was arrested by means of KRA cuff for as long as 100 seconds on 11 schizophrenic patients. Comparing the schizophrenic patients to the normal subjects, recovering time from unconsciousness was prolonged. All subjects regained consciousness within 30 to 40 seconds after

restoration of cerebral circulation and were able to walk from the room within 2 minutes after the procedure. During the arrest of cerebral circulation, loss of consciousness, convulsion, marked cyanosis, involuntary urination and defecation, bradycardia, dilatation of the pupils and changes in reflexes were recorded. Consciousness was recovered rapidly, and no injury or later symptoms were ever noted. The preengorgement obstructed the venous return without affecting the arterial inflow. Within 1 second after release of the preengorgement pressure, the cuff was inflated to produce acute arrest of the cerebral circulation. Although preengorgement had no effect on the time to fixation of the eyes, recovering time following acute arrest of cerebral circulation was significantly reduced by preengorge produced by applying a pressure of 80 – 85 mmHg in the KRA cuff for 15 – 18 seconds to ment.

HUMAN EXPERIMENT OF SHIME WAZA IN JUDO

Physiological studies on fainting due to *shime waza* have been carried out by Japanese judoka and sports scientists since the middle of the last century, and further studies have been reported by western doctors since 1980s.

Japanese physiological studies on fainting due to *shime waza*

The first physiological study on fainting due to *shime waza* was reported by Tadao Ohtaki (1950) in Japanese journal "Tai-iku" (athletics) which was followed by Katsuya Suzuki (1958), Michio Ikai, et al. (1958) and some sports scientists as shown in Table 1.

1) Subjects and Techniques of *shime waza*

Three to 9 black belt judoka volunteered to human experiments. Kata juji jime was mainly used, and okuri eri jime (sliding collar strangle) and Hadaka-jime (naked strangle) were applied to compare the effects of these techniques.

Table 1 Japanese physiological studies on fainting due to *shime waza*

Author	Year	Subjects (number)	Technique of shimewaza	Time to fainting (seconds)	Time to revival (seconds)	Physiological findings
Ohtaki	1950	Black belt Judokas (4)	Katajuji-jime	8 - 14	7 - 12	Dilatation of pupils BT up (> 30mmHg), HR ••
Suzuki	1958	Black belt Judokas (9), Physician (1)	Katajuji-jime Manchette	8 - 37	7 - 18	Dilatation of pupils, upward deviation of eyeballs, BP up, HR up, clonic convulsion, EEG: high amplitude slow wave at fainting
Ikai	1958	Black belt Univ. Students (5)	Okurieri-jime Katajuji-jime Hadaka-jime	10 SpO ₂ 82 – 86 %	10 – 12 SpO ₂ 90 – 92 %	BP up (> 30 – 40 mmHg), HR •• Tonic & clonic convulsion, EEG: slow wave (-), Carotid sinus reflex (???)
Ogawa	1963	Black belt Univ. Students (5)	Okurieri-jime	8 – 14 SpO ₂ 82 – 86 %	10 – 12 SpO ₂ 90 – 92 %	BP up (> 30 – 40 mmHg) HR • •
Shibayama	1978	Black belt Univ. Students (3)	Okurieri-jime Katajuji-jime	6 - 10	NA	Convulsion, HR up (14%), Systolic/diastolic BP up (>20/10 mmHg) after awakening

BP: blood pressure, HR: heart rate, EEG: electroencephalography, SpQ: oxygen saturation of peripheral artery NA: not available

2) Time to fainting after start of *shime waza* and revival after release of *shime waza*

It took about 6 – 14 seconds to fall unconscious after application of *shime waza*, however a prolonged time of 37 seconds was required to choke out an occasional big and expert judoka. Most of the subjects woke up spontaneously in 7 - 18 seconds without a help of kuatsu (traditional resuscitation techniques to push the abdomen or chest wall) (Nimura, Higaki, Motohashi, & Yokoyama, 2021).

3) Physiological response to *shime waza*

The pupils were dilated before falling unconscious, and eyeballs deviated upwards during unconsciousness. Blood pressure (BP) rose about 30 mmHg immediately prior to falling unconscious or after releasing *shime waza*. Heart rate (HR) slightly increased during choking, further increased after awakening and gradually returned to normal. Peripheral oxygen saturation (SpO₂) measured at the helix of the ear dropped to 82 – 86 % during fainting, rose to 90 - 92 % at awakening and 95 % at 20 seconds after release of *shime waza*.

Although Japanese sports scientists made a comment that these cardiovascular responses may be related to carotid sinus reflex (CSR), an increased BP and HR during *shime waza* is not consistent with the symptoms of CSR. In this regard, the interpretation of physiological data during *shime waza* by Japanese sports scientists was at least partly inappropriate. Most of the subjects developed tonic and clonic convulsion after falling unconscious, and EEG showed high amplitude slow waves (delta waves) at fainting (Table 1) (Ikai, et al., 1958; Ogawa, 1963; Ohtaki, 1950; Shibayama & Ebashi, 1978; Suzuki, 1958).

Modern physiological studies on fainting due to *shime waza*

Since 1980s, medical doctors from western countries have reported interesting physiological studies on *shime-waza* by means of modern diagnostic equipment: Laser Doppler velocimeter by Reay and Holloway (1982) at University

of Washington, 133Xe inhalation technique by Rodriguez et al. (1991) at University of Genoa to measure regional cerebral blood flow (rCBF), near infrared continuous wave spectroscopy (NIRcws) by Haga (2016) at Tsukuba University in Japan to measure cerebral oxygenation, transcranial Doppler sonography by German doctor Raschka, et al. (1998), Mitchell, et al. (2012) at University of Calgary and measurement of blood flow in the middle cerebral artery (MCA) during *shime waza* by Haga, et al. (2016). In addition, HR, BP, rate of change of pressure (dP/dt) and cardiac stroke volume in one beat were measured using infrared finger photoplethysmography by Mitchell et al. (2012).

1) Subjects and techniques of *shime waza*

A professional judo teacher or certified instructor performed *shime waza* on 4 - 24 black belt judoka, police officers or athletic law enforcement volunteers. Kata juji jime or carotid sleeper hold was used to choke the subjects.

2) Time to fainting after start of *shime waza* and revival after release of *shime waza*

It took about 7 - 15 seconds from beginning of *shime-waza* to fall unconscious or to tapping out. The choked out subjects spontaneously revived almost immediately or in about 10 seconds after release of *shime waza*.

3) Physiological responses to *shime waza*

BP and HR increased or did not change significantly in majority of the subjects, although those values decreased by about 30 % in a small number of cases. Cardiac stroke volume and dP/dt remained consistent during *shime waza*. Blood flow velocity and volume of the MCA and internal carotid artery (ICA) were reduced by 80 - 90 % during *shime-waza* and completely cut off at tapping out just prior to losing consciousness. Immediately after release of *shime-waza*, the blood flow velocity markedly increased and returned to its previous resting level in 15 to 30 seconds (Figure 4). Oxygenation in the brain abruptly decreased after starting *shime waza* and reached its lowest level at tapping. SpO₂ also dropped to 90 % at tapping.

Figure 4

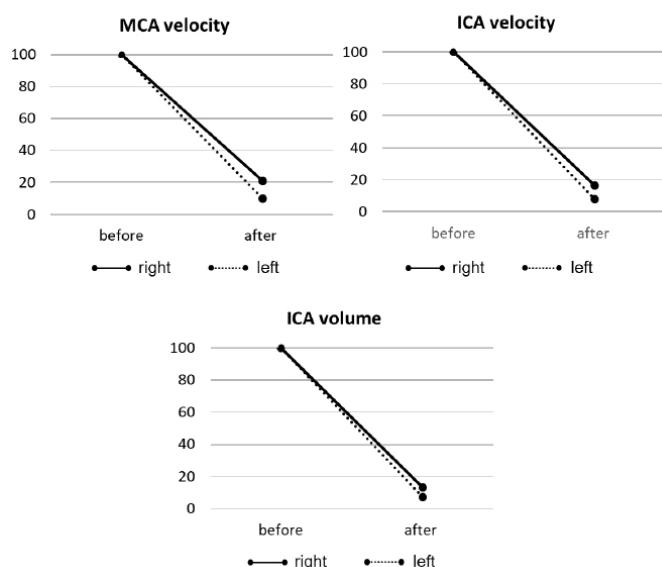


Figure 4. Relative changes in blood velocity and volume before and after application of *shime waza* (Cerebral blood flow velocity and volume are reduced by 80-90 % during *shime waza*; MCA: middle cerebral artery, ICA: Internal carotid artery)

EEG was used to investigate the functional changes of the brain during *shime waza*. A significant increase of slow wave (delta wave) was observed about 7 - 11 seconds after begin-

ning of *shime-waza* and persisted for 5 - 6 seconds (Table 2) (Haga, et al., 2016; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Raschka, Rau, Hubsch, Brunner, & Banzer, 1998; Rau, Raschka, Brunner, & Banzer, 1998; Reay, & Holloway, 1982; Rodriguez, et al., 1991). Furthermore Rodriguez, Vitali and Nobili (1998) performed EEG and measured rCBF in 10 judoka, 24 amateur and 20 professional boxers. The long-term effects of boxing and judo-choking techniques on brain function between the 3 groups were compared. Moderate EEG slowing occurred in both frontotemporal regions in 1 amateur and 2 professional boxers. In contrast, all judokas had a normal EEG. Professional but not amateur boxers had significant cerebral hypoperfusion in the anterior and posterior regions of the brain. However, judoka had normal rCBF even after repeated fainting due to *shime-waza*. They concluded that judoka seemed to be free from central nervous system dysfunction even after repeated *shime waza* with or without fainting (Rodriguez, Vitali, & Nobili, 1998).

DISCUSSION

Cause of fainting (carotid artery compression or CSR?) and associated symptoms

Although Japanese physiological studies on fainting due to *shime waza* were initiated by sports scientists, their published human experiments were just like case reports including 5 subjects or less without statistical analysis of their study results. In addition, there were several inap-

Table 2 Modern physiological studies on fainting due to *shime waza*

Author (country)	Year	Subjects (number)	Techniques of shimewaza	Time to fainting (seconds)	Time to revival (seconds)	Physiological findings
Reay (USA)	1982	Athletic law Enforcement Volunteers (5)	Carotid Sleeper hold	6.0 (3.2 – 7.2)	13.7 (7.3 – 23.0)	ECA blood flow by laser Doppler, Time to minimum flow: 6.0 (3.2 – 7.2) sec. % decrease in flow: 89.4 %, BP, HR: variable response depending on the subjects
Rodriguez (Italy)	1991	Judokas (M 9, F 1)	Katajuji-jime	7 - 10	10 - 15	Fainting with convulsion, EEG: slow (delta) waves, No nervous dysfunction by repeated choking
Rau (Germany)	1998	Jujutsukas, Judokas (6)	Katajuji-jime	8 • • 1.8 (choking time)	NA (no fainting)	EEG: Significant increase of slow (delta) waves and Decrease of alpha waves after choking
Raschka (Germany)	1998	Black belt Judokas (8)	Juji-jime	9 • • 1.7 (choking time)	NA (no fainting)	BP dropped by 10.6% from an average level, Blood flow velocity (MCA, ICA) • • ; volume (ICA) • •
Mitchell (Canada)	2012	Police officers (24), (M21, F3)	Carotid Sleeper hold	9.5 – 11.0	almost immediately	BP, HR : No significant changes, MCAvelocity • • ; Unconsciousness (16/24), No evidence of CSR
Haga (Japan)	2016	Black belt Students (4)	Katajuji-jime	10.75 (7 – 15)	NA (no fainting)	BP up (10 – 20 mmHg), HR up (10/min), SpO ₂ : 89.8 % at tapping

ECA: external carotid artery, ICA: internal carotid artery, MCA: middle cerebral artery, EEG: electroencephalography,

Bp: blood pressure, HR: heart rate, M: male, F: female, NA: not available

appropriate medical descriptions in their papers even though some medical doctors participated in those study groups. For instance, Suzuki (1958) and Ikai et al. (1958) made an inappropriate comment about possible cause of unconsciousness due to CSR, although their results did not show any positive evidence of bradycardia and hypotension specific to CSR (Ikai, et al., 1958; Suzuki, 1958). Similar comments have been made one after another by Japanese sports scientists although they were not able to find any evidence of CSR in their human experiments of *shime waza* (Haga, 2016; Ogawa, 1963; Shibayama & Ebashi, 1978; Tezuka, 1978).

The carotid sinus is a dilated area at the proximal end of the internal carotid artery just above the bifurcation of the common carotid artery into the internal and external carotid artery. The carotid sinus consists of various nerve receptors which regulate blood pressure and heart rate (Figure 5). External mechanical stimulation of the carotid sinus causes suppressive changes in heart rate and blood pressure leading to decreased blood flow to the brain followed by temporary loss of consciousness that sometimes accompanies convulsive seizures. Carotid sinus massage is sometimes useful for differential diagnosis of tachycardia diseases. It is clinically used to investigate a cause of dizziness, syncope, or unexpected falls in old patients, because these symptoms can be induced by cerebral ischemia (Munro, 1994).

Western medical doctors contributed to the progress of physiological studies on fainting due to *shime waza* using modern diagnostic techniques such as infrared finger photoplethysmography, Doppler ultrasonography, ¹³³Xe-non inhalation method to measure BP, HR, blood flow of MCA, rCBF, EEG and long-term effects on the brain function. They scientifically demonstrated physiological changes in cerebral blood flow which cause fainting due to *shime-waza*. In contrast to the Japanese researchers, western doctors finally concluded that the causative factor of fainting due to *shime waza* is not CSR but decreased cerebral blood flow with no significant change in HR and BP by mechanical compression of bilateral carotid arteries. In addition to the above results, typical EEG findings of carotid sinus syncope are increased frequency of brain waves, however, large slow waves (delta waves) without increase of frequency are characteristic of fainting due to carotid artery occlusion. Furthermore, they revealed that judoka seemed to be free from central nervous system dysfunction even after repeated loss of consciousness due to *shime waza* (Mitchell, et al., 2012; Raschka et al., 1998; Rau, et al. 1998; Reay & Holloway, 1982; Rodriguez, et al., 1991).

Is *shime waza* induced fainting dangerous?

Koiwai (2005) reported 14 fatal accidents due to "Choke hold" (*shime waza*) by law enforcement officers in the USA. More than half of the victims were drug abuser or inmates with psychiatric problem, prolonged combativeness or cardiovascular diseases who died suddenly after the choke hold for a few

seconds. Autopsy revealed that the cause of death was asphyxia because of neck compression during restraint procedure. Later however, most of those deaths were categorized as "Sudden in-custody deaths" which were not related to judo practice but occurred after violent confrontation with law enforcement officers who used neck holds with or without forcible control materials: choke stick, baron or flashlight. As these techniques, however, have increased a risk of serious neck injuries, only carotid sleeper hold is now allowed to use as an appropriate technique to avoid fatal accident (Koiwai, 1987; Ross & Chen, 2006).

On the other hand, Owens et al. (1991) at University of Liverpool reported a patient with brain damage possibly due to frequent strangulation during his judo career as an international class expert. This patient suffered from occasional loss of consciousness and persisting difficulties with memory. Neurological examinations suggested that cumulative effects of *shime waza* might have been one of the causes of brain damage. However, the authors did not show any findings in the MRI to investigate the brain vascular disease (Owens & Chadiali, 1991).

When a stroke occurs during contact sports, carotid arterial diseases should be considered. The author (Y.N.) reported a case of cerebral infarction due to *shime-waza* at the 2017 EJU Medical Seminar at Antwerp. A 60-year-old judo instructor developed disturbed consciousness and left hemiplegia during teaching *shime-waza* for his young student by being strangled himself. Urgent examination revealed right cerebral infarction due to right carotid artery obstruction caused by a thrombus which might have developed from atherosclerotic carotid artery during *shime-waza*. This judoka could survive an urgent decompressive craniectomy with medical treatment of carotid arterial thrombosis and discharged the hospital with persisted left hemiplegia, hemianopsia and higher brain dysfunction (Kato, et al., 2017; Nimura, 2017).

Unconsciousness induced by *shime waza* is associated with neurological symptoms, i.e., convulsion, dilatation of pupils, upward deviation of the eyeballs, drooling, tingling pain, incontinence and mental state impairment which are observed not only in human experiments of *shime-waza* but also during judo practice and competitions. Matsunaga, et al. (2021) studied acute and late phase consequences of fainting due to *shime waza* and revealed that repetitive fainting due to *shime waza* did not lead to any residual neurological disabilities in judoka's lifetime. Carotid and cerebral artery occlusive diseases also develop similar symptoms. Carotid artery occlusive diseases develop hemiplegia and hemianesthesia. Incontinence and mental state impairment, i.e., confusion and amnesia are observed in patients with anterior cerebral artery obstruction. Speech impairment, partial blindness and deviation of the eyeballs are observed in MCA obstruction. Hemianopia (blindness in half vision), memory impairment and tingling pain are observed in patients with posterior cerebral artery occlusive disease (Figure 5). As these findings look cruel, possible danger of *shime waza* has been discussed. Haga, et al. (2016) were anxious about temporary decrease of

cerebral blood flow during shime-waza. However, temporary cerebral ischemia has not been followed by any injurious effects as shown in the previous reports (Haga, et al., 2016; Ikai, et al., 1958; Rodriguez, et al., 1991; Shibayama & Ebashi, 1978; Suzuki, 1958).

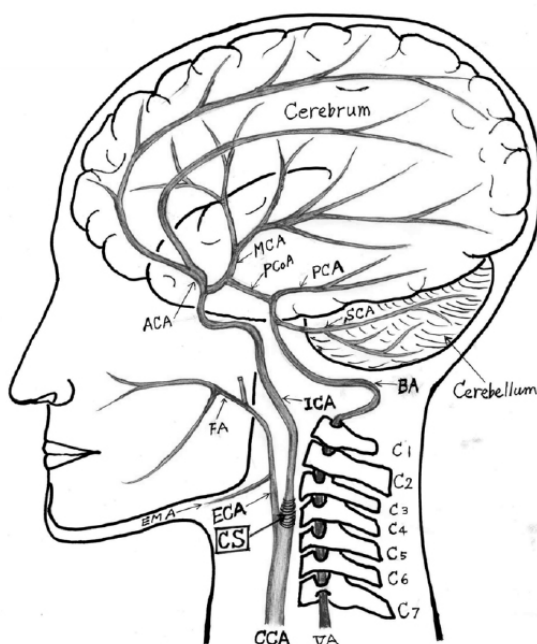


Figure 5. Arterial anatomy of the head and neck and carotid sinus. Note: The carotid sinus (CS) is a thin-walled dilated area located at the proximal end of the internal carotid artery (ICA) just above the bifurcation of the common carotid artery (CCA). ACA, anterior cerebral artery; BA, basilar artery; C1-C7, cervical spine; CCA, common carotid artery; CS, carotid sinus; ECA, external carotid artery; EMA, external maxillary artery; FA, facial artery; ICA, internal carotid artery; MCA, middle cerebral artery; PCA, posterior cerebral artery; PCoA, posterior communicating artery; SCA, superior cerebellar artery; VA, vertebral artery

Unconsciousness associated with convulsion is also observed during breath-holding spell which is occasionally encountered as the episodic apnea in crying children between 6 and 18 months old. This eventually leads to a significant decrease of blood flow to the brain. The children usually recover within 1 – 2 minutes. Similarly, convulsive syncope can be induced by breath-holding spell (Weber maneuver or Valsalva maneuver) which is performed by moderately forceful attempted exhalation against the closed airway, usually done closing one's mouth, pinching one's nose shut while expelling air out as if blowing up a balloon. This maneuver never necessitates strangulation of the neck. Unconsciousness lasted about 12 (6 – 22) seconds and myoclonus occurs in about 90 % of syncope episodes. Loss of consciousness coincides with EEG patterns of progressive slowing (delta wave), which reflects the progressive suppression of cerebral electrogenesis by anoxia. Myoclonic jerks occur during this stage as an integral part of the cerebral response to anoxia. Diaphoresis, drooling and/or incontinent of urine are sometimes noted while unconsciousness (Matsunaga, Nimura, Sugimoto, Mizutani & Yokoyama, 2021). Eyes remained open throughout fainting in most subjects and initial upward deviation of the eyeballs was

commonly observed. The stage of cortical suppression and medullary activation coincides with loss of consciousness and subsequent myoclonus. Relative differences in anoxic convulsion in judo would seem to reflect the rapidity of onset and the duration of the cerebral anoxia (Duvisin, 1962; Lempert, Bauer, & Schmidt, 1994).

Ethical issues in human experiments of *shime waza*

In 1940s, human experiments of acute arrest of cerebral circulation were performed

without approval by the ethical committee and without informed consent of the subjects. The ethical framework for such research now seems unacceptable, but ethical norms for research were not well defined at that time. The ethical propriety of their study perhaps best evaluated in the context of the time period in which they were performed, as well as by how the results were required. One key aspect of the study was the fact that all involved were part of an intense national push in support of the War effort. Doubtless, informed consent, as we know it today, was not obtained. The prison physician reported that there were no bad effects of any kind and the subjects would submit to further tests if called upon to do so, because they thought they contributed their bit toward the war effort. In fact, several inmates volunteered as many as 9 times. In the patriotic fever at this time, genuine informed consent would probably have been challenging to obtain in a study of this kind, even if it had been sought (Smith, Clayton, & Robertson, 2011). Mitchell's study protocol of human experiment could be approved by the Institutional Conjoint Health Research Ethics Board. However, any protocol of human experiment to choke out judoka may not be approved by recent scientific research committee and ethical board, despite many scientists have revealed that fainting due to shime-waza were safe without any acute and delayed side effects (Matsunaga, Nimura, Sugimoto, Mizutani, & Yokoyama, 2021; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Rodriguez, Vitali, & Nobili, 1998).

Safety management of choked-out judoka

From the perspective of safety management of choked-out judoka during practice and competition, it is important to establish a standard procedure to treat the fainting judoka. Kuatsu has been used by judo teachers and referees in Japan as a traditional and effective technique to awake a choked-out judoka in about 3 seconds. This conventional technique is useful to shorten the fainting time with or without associated symptoms such as oculogyric crisis (upward deviation of eyeballs), convulsion, drooling and/or incontinence (Matsunaga, Nimura, Sugimoto, Mizutani, & Yokoyama, 2021; Nimura, Higaki, Motohashi, & Yokoyama, 2021). On the other hand, when the competitor is choked-out in Brazilian Jiu-jitsu, the referee grasps the ankles with both hands and lift the legs of the fainting competitor to restore blood flow from the lower body back up to the head and to revive the fainting athlete (Figure 6). (<https://www.bjje.com/articles/what-to-do-when-someone-is-choked-out/>).



Figure 6. Leg-lifting method to revive a choked out athlete (The medical value of this method is questionable)

Similar procedure is called as “passive leg raising” (PLR) in emergency medical practice to lay a patient flat on the bed with legs elevated on a 45-degree incline (Figure 7). PLR is used in Emergency Medicine Service in the hospital as a valid treatment option for patients with hypovolemia (a lack of blood volume in the cardiovascular system) due to massive bleeding or some critical conditions. Those emergency conditions make the heart unable to pump enough blood to the body. It is known that PLR transfers a volume of around 150 – 300 ml of venous blood from the lower body toward the right heart which leads 9 % increase in cardiac stroke volume and 10 % increase in blood pressure, although its effects may vanish after 1 minutes. PLR should be avoided for patients with head trauma because this procedure can increase intracranial pressure (Boulain, Achard, Teboul, Richard, Perrotin, & Ginies, 2002; He, & Liu, 2016; Monnex, Rienzo, Osman, Anguel, Richard, Pinsky, & Teboul, 2006; Monnex, & Teboul, 2015).

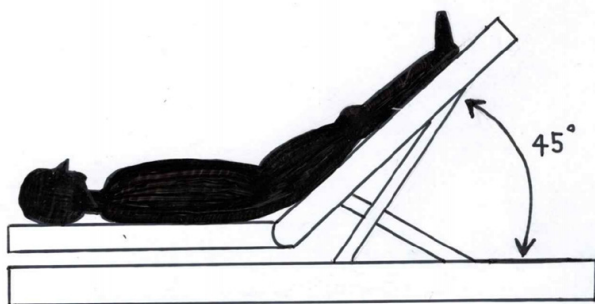


Figure 7. Passive leg raising on a 45-degree incline on the bed in Emergency Medicine Service (this method returns venous blood from the lower body to the right heart to increase cardiac stroke volume in patients with hypovolemia)

However, “leg-lifting method” was incidentally found to be used by a medical staff to revive a choked-out judoka in

2020 Tokyo Olympic Games, although medical benefit of this procedure has not been clarified in the first-aid treatment for a choked-out athlete in judo and Brazilian jiu-jitsu. As shown above in the results of human experiments, any clinical sign of heart problem such as hypovolemia with hypotension and tachycardia, or shock with signs of pallor, prostration, perspiration, pulmonary insufficiency and pulseless were not observed in the choked-out subjects who spontaneously revived in 7 - 18 seconds after release of choke hold. Therefore, “leg-lifting method” is not a valid treatment option for awakening the fainting judoka. The authors recommend following strategy in the treatment of fainting judoka due to *shime waza* during practice and competition (Nimura, Higaki, Motohashi, & Yokoyama, 2021).

1. Release the *shime waza* immediately when you find the opponent taps or unconscious.
2. Don't panic and carefully observe the respiration and appearance of the fainting judoka who will revive spontaneously in about 10 seconds.
3. As fainting judoka sometimes develops unpleasant symptoms such as oculogyric crisis (upward deviation of eyeballs), convulsion, drooling, and incontinence. Kuatsu is recommended to shorten the period of unconsciousness with associated symptoms which disappear at the time of awakening.
4. Don't pull up the fainting judoka to sit up on the tatami to use sasoi-kuatsu, the most popular method of kuatsu, because of a risk of neck injury due to over anterior flexion of the neck during the procedure.
5. Passive leg raising is not recommended as a treatment option for fainting judoka due to shime-waza during practice and competition, because the choked-out judoka does not develop hypovolemia or shock during fainting.

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Article history

Received: 06 September 2021

Accepted: 08 April 2022



How Expert Coaches Understand The Application of Rhythm in Judo

By Georgios Bountakis & Mike Callan

Abstract: *The goal of this study is to learn about the use of rhythm in judo through the eyes of skilled Japanese trainers. In their native language, six expert Japanese coaches were questioned. The transcripts were coded using the automatic analysis software and Interpretive Phenomenological Analysis (IPA) was used to analyse them. The IPA method was used for this study because it enabled the data to provide the framework for themes rather than the researcher influencing them.*

Rhythmic training was used for a variety of reasons, including quicker technical improvement, better attack or defence, fitness, speed, skill acquisition, and personal and spiritual growth, according to interviewees. Both the interviews and the codification process resulted in fresh discoveries about the use of rhythm in judo and judo as a pedagogical tool. In the context of training, the rhythm was regarded as an integrated and representational aspect.

This research looks at how professional coaches apply rhythm in judo and gives us some insight into how they think about it. It demonstrates that outside of the training setting, coaches play a significant role for students by educating, coaching, and guiding them. Humans, body, opponent, rhythm, tai sabaki, technique, breakfalls, and training are among the 154 textual pieces divided into eight categories. Human movement, judo rhythm, teaching method, and technical skills emerged as the four key topics.

Keywords: *judo; harmony; rhythm; pedagogy; skills; movement*

Rhythm in judo is a concept that draws together a variety of topics including judo history and body movements also found in dance. A detailed study of what expert judo coaches understand by rhythm in judo has not previously been carried out. This study seeks to address that with detailed research aims outlined below.

In Japanese, the word 'judo' is written using the ideograms 柔道 and means 'gentle way' (嘉納治五郎, 2005). Professor Jigoro Kano graduated from Tokyo Imperial University with a degree in Literature in 1881 and a degree in Philosophy the following year. He established the Kodokan as a school to teach the art of judo, which was an amalgamation of many *ju-jutsu* systems. *Ju-jutsu* was established by Samurai warriors (lit. "one who serves") to enable them to battle opponents in hand-to-hand combat. With the Meiji restoration in 1868, their reign came to an end (Brousse & Matsumoto, 1999; Japan, 2019; Kanô & Cadot, 2013; *The History of Judo*, 2019), their legacy, however, goes on throughout the history of judo and martial sports. According to Hoare (2009), the origins of judo are linked to Japanese battle traditions, life arts, and Kano's personality (Hoare, 2009).

Dance has been a sign of conscious awareness of the existence of life since ancient times, due to the idiosyncrasies of rhythm, and it performed an important and neces-

sary function in the period before visual art. This may be found in ancient cultures all across the world when people dance for religious purposes (Sfetcu, 2014).

Aristotle (384-322 BCE) characterised education as a combination of music and gymnastics, while Socrates (470-399 BCE) advocated for more widespread dance instruction, claiming that "*those who honour the gods best with dances are best in combat.*" In his book "Laws," Plato (427-347 BCE) said, "*So the well-educated man may learn to sing and dance well,*" and devoted much of his emphasis to the value of dance instruction.

Dance instruction, like judo, is a somatic experience with the ultimate objective of developing a competent body. Players who receive quality training have a greater awareness of their bodies, which leads to improved movement control, which is critical for judo athletes. This training is found in Japanese kabuki dance (Hahn, 2007), the Greek syrtaki dance, (Zografou & Pateraki, 2007), and in walking techniques used in the traditional and Olympic sports of Japanese judo and Greek wrestling.

Despite the fact that there is no study in the field of judo that tackles why rhythm is vital, scientists and experienced trainers believe that rhythm is a crucial skill in people's everyday life. People who have a strong sense of rhythm

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move better, breathe better, and start and end work on time. In sports, motion and dance can help not just with performance but also with injury reduction or prevention. Those who have a natural rhythm may be able to develop their technique more quickly than others. This study aims to learn more about the relevance of rhythm in judo by looking into how skilled coaches see its application.

A review of the literature revealed no thorough information on judo rhythm and how it might be utilised to improve athletes' abilities. The information was gathered from the researcher's first-hand conversations with experienced Japanese teachers.

AIMS OF THE RESEARCH

The aim is to explore how expert coaches understand the application of rhythm in judo. There is currently no research in the field of judo that addresses the question of why rhythm is important. Scientists and experienced coaches agree that rhythm is an important skill in the peoples' everyday lives (Reilly, 2009).

Judo is made up of three core tools for instruction or practice: *kata*, *randori*, and *shiai*. Because those three basic training methods have remained unchanged, three research questions connected to this study were developed:

- 1) *kata* stage (fundamentals); how do high-level teachers perceive the contribution of rhythm to the first steps of the practitioners?
- 2) *randori* stage (free training); how do high-level teachers evaluate the importance of rhythm in randori and its relationship in daily training?
- 3) *shiai* stage (contest); how do top-level players use rhythm for offence / defence?

METHODOLOGY

Interpretative Phenomenological Analysis (IPA) was used to address the study topic, and the technique included interviews with top-level national coaches and university professors. Ethical approval was given by the University of Hertfordshire's School of Life and Medical Sciences Ethics Committee.

The goal of phenomenology is to understand how people make sense of their lived experience (Starks & Brown, 2007), and to elicit a detailed account of a personal event. Phenomenology studies the experience and meaning of phenomena in order to identify phenomena and unearth previously undetected or missed concerns. As a result, rather of forming conclusions, phenomenology unveils 'hidden' meanings or identifies the influence of a phenomena. Simultaneously, this technique gives detailed explanations that enhance comprehension. Researchers may be better able to appreciate the possibilities embedded in the experience of events as a result of acquiring this information (Lutz, 2013).

IPA research, according to Conrad (1987), is a dynamic process in which the researcher strives to take an insider's viewpoint on the participant's experience. Participants are specialists in their fields of experience and, by extension, the subject under examination. According to Conrad (1987) IPA research is conceptualised as a dynamic process where the researcher attempts to assume an insider perspective on the participant's experience. Participants are experts of their experience, and by implication, of the topic under investigation (Osborn & Smith, 2008). According to Smith and Osborn (2004; p. 211) the use of IPA is "particularly suitable where the topic under investigation is novel or under-researched. Where the issues are complex or ambiguous and where one is concerned to understand something about process and change".

For these reasons IPA was preferred as the thematic analysis methodology.


A key informant sampling approach is a research approach whereby key informants are utilised as expert sources of data. Because of their own abilities, key informants are able to supply more information and provide a better understanding of what is going on around them (Marshall, 1996). The key informant approach is a qualitative research method that has been successfully and widely applied in a variety of social science studies. The quality of data that may be acquired in a short amount of time is a benefit of the key informant approach (Marshall, 1996).

As the study seeks to elicit the views of expert coaches on the topic of rhythm in judo, it was felt necessary to apply the principles of key informant sampling to identify the experts. The approach taken is explained below.

The International Judo Federation (IJF) and Kodokan Judo Institute, have a ranking system criteria (IJF, 2018), such as dan grade in combination with age, which leaves no room for misunderstanding about who is an expert and who is not. In this study, the sample selection criteria are in line with the research question and in accordance with the standards of the IJF.

The 1st through 5th dan (degrees) are indicated as low grades, even the minimal age for the 5th dan (29 years) is not regarded enough experience to qualify someone as a high grade. In addition, a practitioner must have been practising judo for at least fifteen years to achieve the 5th dan. Two of the eight variables in the current study (age and belt degree) are based on international standards (see Figure 1).

In certain circumstances, IPA investigations focus just on one participant's experiences and behaviours. However, a modest number of people, such as six, has been proposed as a reasonable amount (Reid et al., 2005). IPA samples tend to be small to allow idiographic data analysis (Smith, 2004). Smith and colleagues (2009) proposed a total of four to ten interviews as standard and suitable. Therefore, a sample of six participants (see interview plan) is sufficient for this research project's high-quality analysis.



International Judo Federation

HIGHT GRADES

National Federation level :

Categories	Minimum Age	Time passed since the last validation	Knowledge of Kata
6th dan	A 30 years	6 years	Koshiki no kata
	B 35 years	8 years	Koshiki no kata
	C 40 years	10 years	Koshiki no kata
	D 50 years	12 years & 25 years of 1 st dan	Koshiki no kata

Continental Union level:

Categories	Minimum Age	Time passed since the last validation	Knowledge of Kata
7th dan	A 38 years	8 years	All kata
	B 45 years	10 years	All kata
	C 50 years	10 years & 25 years of 1 st dan	All kata
	D 62 years	12 years & 30 years of 1 st dan	All kata

Figure 1. IJF high grades - Source: International Judo Federation. Dan Ranks and Grades (2018) <https://www.britishjudo.org.uk/wp-content/uploads/2021/03/IJF-DAN-Ranks-Grades-ENG.pdf>

A sample from a selected base of minimum 40 years old (category c) and 6th Dan, gives an average experience of involvement with judo of 25 years from 1st Dan (black belt) to 6th Dan (red and white).

Collins (2009) argues that, traditionally, coaches placed the emphasis on teaching Japanese terminology and demonstrating techniques. Collins stated that, “*although demonstrating techniques from the belt system is necessary for students to progress through the belt syllabus, this appears to be a seemingly outdated approach for modern day competitive judo coaching as it is not preparing judo participants effectively for high-level judo competition*” (Collins, 2009). However, recent data does not support the notion that conventional fundamentals-based training is an out-of-date strategy for modern competitive judo coaching. The traditional Japanese teaching style has been effective in high-level judo contests such as Olympic Games and World Championships over the years by emphasising basics (see Table 1). Gender and nationality were the other two criteria for the participants in this study.

According to (Lutz, 2013), martial arts remain a mostly male-orientated activity. A recent UK-based survey with practitioners of various martial arts found that over three quarters of respondents were male (Jones et al., 2006). An earlier survey on sport in England also reported more male participants in martial arts (England, 2002). This bias is in part reflective of the greater overall participation of men in sports worldwide.

Table 2. Minimum Sample Selection Criteria

Age	Gender	Nationality	Rank	Graduate	Training duration	Teaching experience	Current role
40	M	JPN	6th Dan/degree	University	25 years	10 years	National Coach or Associate Professor

According to an examination of the literature, there is no research on rhythm in judo, except for allusions in publications by Japanese judo specialists, making this a ground-breaking study. Japanese experts describe the importance of rhythm in judo in a variety of ways, as well as providing a description of judo rhythm. As a result, Japanese specialists are more suited for this study.

Another reason Japanese experts are ideal for this study is that judo is ingrained in their culture, and second, Japanese experts are guided by international outcomes, including world championships and the Olympic Games, which are regarded as the most important competition in the sport (Daniel & Daniel, 2013; Ferreira Julio et al., 2013; Franchini & Julio, 2015; Franchini & Takito, 2014; Guilherme & Franchini, 2017; Niehaus, 2006; Sato, 2013; Villamón et al., 2004).

The Table 1 shows the top gold medal-producing countries in either the Olympics or World Championships since 1956 (Ohlenkamp, 2004).

Table 1. Top 10 Countries

GOLD MEDALS	1956-2004
Japan	120
France	39
Korea	28
Great Britain	17
Cuba	16
Former Soviet Union	16
China	16
Germany	15
Netherlands	14
Belgium	11

Source: Neil Ohlenkamp, “Olympic and Championship Judo Analysis” <https://judoinfo.com/champs2/>

Training in judo is based on three basic methods, *kata* (formal exercises), *randori* (freestyle fighting), and *shiai* (matches), (Kano, 1932). According to Kudo, (1967) *judoka* must have an in-depth experience in each of those three elements.

Three (3) top university professors and three (3) high-performance coaches, all of whom have won Olympic medals, were chosen for this study. Teaching experience and present status (national coach or associate professor) were two additional factors considered throughout the selection process (see Table 2).

The following table provides an overview of individual participant profiles, outlining demographic characteristics, experience in judo and roles. Pseudonyms have been used to ensure anonymity (see Table 3 & 4).

Table 3. Participants' Profiles

Participant	Age	Nationality	Belt rank	Graduate	Training duration	Teaching experience
Kom	68	JPN	8 th cat, A	Tokyo University	56 years	46 years
Mit	69	JPN	8 th cat, A	Tokai University	59 years	47 years
Yam	50	JPN	7 th cat, C	Tokai University	46 years	27 years
Mas	49	JPN	7 th cat, B	Tsukuba University	39 years	19 years
Ino	41	JPN	7 th cat, A	Tokai University	36 years	12 years
Kan	40	JPN	6 th cat, C	Tsukuba University	35 years	11 years

INTERVIEWS

Smith and colleagues (2009) recommended adopting an interview plan for semi-structured interviews in order to allow thoughts on the expected range of the topic area and potential challenges throughout the interview. A 'funnelling' approach was used to select and organise interview questions (Osborn & Smith, 2008), with inquiries that progress from general to specific and specialised. This method makes it easier for interviewees to talk about the subject matter and allows them to have a better grasp of it throughout the interview (Tindall, 2009).

Table 4. Interview Questions in Relation to Research Questions

	Research Questions	Interview Questions
Question 1	<i>Kata</i> stage, How high-level teachers perceive the contribution of rhythm in the first steps of the practitioners?	<p>1.1 <i>Ukemi</i> is fundamentally the first thing practitioners learn in judo, how <i>ukemi</i> relate to rhythm?</p> <p>1.2 Teachers mentioned <i>tai sabaki</i> as a toll for athlete to use body rhythmically, please can you explain more? How <i>tai sabaki</i> can teach the athlete to use his body rhythmically?</p> <p>1.3 <i>kuzushi</i>, <i>tsukuri</i>, <i>kake</i>, is the three faces of throwing, based on your experience how rhythm connect?</p>
Question 2	<i>Randori</i> stage, How do high-level teachers evaluate the importance of rhythm in <i>randori</i> and its relationship in daily training?	<p>2.1 What aspects of training have been an important part in rhythm development?</p> <p>2.2 In what ways, can you help your students develop rhythm in <i>randori</i>?</p> <p>2.3 Please can you describe to me what is rhythm in judo for you?</p>
Question 3	<i>Shiai</i> stage, How top-level players can use rhythm for offence/defence?	<p>3.1 Teachers mentioned the important of rhythm in <i>randori</i> in order players transfer rhythm in to <i>shiai</i> too, please explain more, why this is important?</p> <p>3.2 Rhythm can be a tool during the training, but during the fight how to break the opponent's rhythm?</p> <p>3.3 Please can you explain more, why it's important to break opponent rhythm?</p>

Data Collection Procedure

The audio-recorded interviews were then translated after each one. Pseudonyms were used in all transcripts for the sake of anonymity. Individual interview transcripts were sent to all interviewees through e-mail. The responders were given this to verify, ratify, and assess the correctness of the information supplied.

The data analysis chiefly followed the analytic process outlined in the literature (Smith, 1995; Tindall, 2009). The interview recordings were reviewed by the researcher and interpreter multiple times. Transcripts were read and re-read repeatedly word for word to ensure accuracy (Fontana & Frey, 2000). For qualitative data analysis, QSR NVivo software (version 12.0 pro) was used to produce preliminary concepts, which were then coded as themes. Following that, NVivo coding was utilised to find sub themes that were comparable. This procedure laid the groundwork for a more in-depth study and the collapse of emerging themes. A comprehensive list of all themes was compiled, and they were categorised into subcategories based on superordinate themes.

System analysis

The IPA qualitative research technique provides researchers with the finest opportunity to comprehend the most in-depth debate about participants' lived experiences. The interpretive phenomenological analysis technique, as a 'participant-oriented' approach, permits interviewers (research participants) to articulate themselves and their lived experience as they see it without distortion. As a result, employing the IPA technique in a qualitative research study reinforces the notion that its primary goal and principle is to examine participants' lived experiences and allow them to express the research results via those experiences (Alase, 2017).

IPA researchers are urged to utilise the procedures proposed by Moustakas (1994) to analyse qualitative data. This research follows the set of analysis methodologies for phenomenological researchers introduced by Moustakas (1994), namely, a set of methodologies that phenomenological researchers were advised to employ in analysing their studies. The goal was that IPA researchers would have a more unified analytic process that reflected their research study's phenomenological philosophy (Moustakas, 1994).

As a starting point for studying the phenomena, Creswell (2013) gave an overview of the history of mixed-methods research and suggested that academics "create a collection of noteworthy remarks." These remarks can be gleaned through interviews and other related research sources that pertain to the experience under investigation. Researchers should "view each assertion as having equal merit and try to construct a list of non-repetitive non-overlapping claims," according to Creswell (2013).

After the development of these statements from the participants, researchers should take the most significant statements and then group them into larger units of information, called themes. The next stage, after grouping the text elements, is to form a large unit of information (Creswell & Poth, 2016).



Figure 2. Analysis Structure Diagram

Themes Results Analysis Model

Initial analysis identified 154 Textual Elements (TE) or phrases uttered during the interviews. These were grouped into 55 subcategories. Then for the next level of analysis, the 55 subcategories were grouped into eight categories: 1. Humans, 2. Body, 3. Opponent, 4. Rhythm, 5. Tai-sabaki, 6. Technique, 7. Breakfalls, 8. Training. Four themes were created based on the above categories; 1. Teaching methods, 2. Technical Skills, 3. Rhythm in judo, 4. Human Movement.

Categories and subcategories were created from the interview data analysis performed for textual elements (TE) and number of interviewees (NI), (see Figure 3).

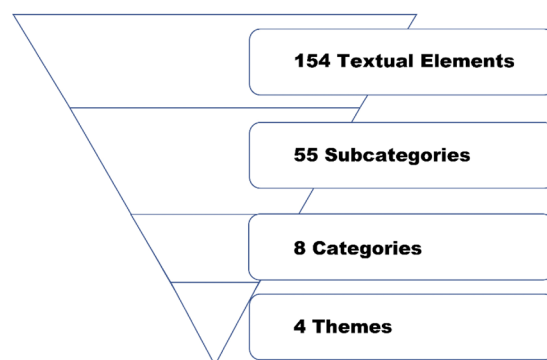
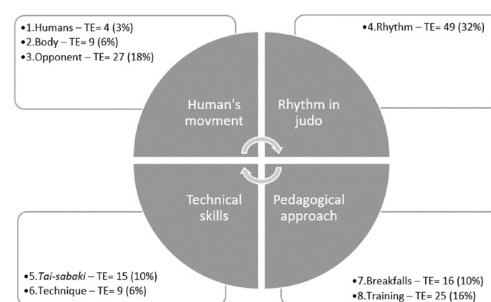


Figure 3. Thematic Analysis Progress

RESULTS

Smith et al (2009) recommended the use of a graphic depiction when analysing larger samples. A diagrammatic model was therefore developed in order to better make sense of, and visually illustrate, the themes in relation to each other (see Figure 4).



Note. TE is the number of Textual Elements that were coded to each of the eight categories.

Figure 4. Model Related to Themes Structure

The six interviews with expert Japanese judo coaches, each contained nine interview questions. An analysis of the transcripts resulted in 154 textual elements being identified. These were allotted to 54 subcategories which were grouped into 8 categories. The 8 categories, mentioned above, were drawn into 4 main themes; Pedagogical approach, Rhythm in judo, Technical skills and Human's movement.

DISCUSSION

Restatement of the Research Problem

This research revealed how a group of expert judo coaches see the use of rhythm in judo, as well as how they analyse rhythm in the context of an athlete's daily life and personal growth. In both the use of rhythm in judo and judo as a teaching tool, the interviews and coding process revealed a number of unanticipated abnormalities.

The summary generally follows the diagrammatic model's organisation of topic areas, which may be thought of as a "guideline" for the most important phenomena. The regularity with which they instinctively alluded to rhythm in judo during the interviews demonstrated its personal relevance. It is critical for rhythm to be second nature, according to interviewees. In the context of training, rhythm was also regarded as an integrated and representational aspect. This framework was deemed necessary in order to provide the reader with a contextualised knowledge of the phenomena that were considered important in this study.

Rhythm training was pursued for a variety of reasons, according to interviewees. Faster technical development, improved attack or defence, fitness, speed, skill acquisition, personal and spiritual growth, and competitive outcomes were among them. The goal of this study was to find out: 1) how high-level teachers see rhythm's role in practitioners' initial steps, 2) how professional teachers assess the value of rhythm in randori and its link to daily training, and 3) how top-level players employ rhythm for offensive and defence.

Pedagogical approach

Pedagogy and training method are two sides of the same coin and Jigoro Kano mentioned many times the importance of the "way" of judo (Kodokan, 2021). The philosophical part of judo is found at every stage of an athlete's development. This can be seen in the various comments given by the expert coaches when interviewed for this study: *"at competition level, it enables you to give your best performance or, depending on how you disrupt your opponent's performance, enables you to perform in a way that is beneficial. This is not just limited to judo or sports but is also found at work and other aspects of life"* (interviewee 6).

Rhythm in judo

"Optimum rhythm and timing for proper, efficient, performance" (Ota, 2019). *Based on this study rhythm in judo is much more than this: "sense of rhythm should not just be treated as an important aspect but thought of as second nature"* (interviewee 4).

Technical skills

Technique is undoubtedly another important point in the basics of athlete development and begins with posture: *"in order for athletes to improve their technique, it is exceedingly important that they repeatedly practice and gain a firm understanding of the logic of the fundamental principles of judo shizentai (natural posture), jigotai (defensive posture), way of walking, control of your body turns"* (interviewee 2).

Human movement

The fact that this theme brings together 40 of 154 text elements shows that participants consider this parameter very seriously: *"Judo is about opponents, human opponents, so you need to have a good understanding of a human's movements. Humans move forwards, backwards, sideways, diagonally. Your opponent will move in those ways and their balance will also adjust itself. If you feel those movements in your own body, it will empower you, and that is very important in judo"* (interviewee 4).

The implications of this study

It's critical to recognise the role of education in a child's first steps on the mat. The findings demonstrate that the educational approach is a crucial component for practitioners, and as a result, athletes who take the tough road are more likely to win medals. Many studies have explored the coach's educational function, and the training process equips practitioners with philosophical and basic ideas that work together for the good of society. Jigoro Kano stated, *"before and after practicing judo or engaging in a match, opponents bow to each other. Bowing is an expression of gratitude and respect. In effect, you are thanking your opponent for giving you the opportunity to improve your technique"*, a statement in which the pedagogical character in teaching judo can clearly be seen. A remark that clearly demonstrates the educational nature of judo instruction.

Another takeaway from the findings is that the athlete's rhythm development must be such that it becomes second nature. The diagrammatic model analysis depicts the role of rhythm in breakfalls, implying that if an athlete develops rhythm to the point where it becomes second nature, he improves his degree of safety in both training and everyday life. All of the above can be summarised in one phrase, *"shin-gi-tai"*, Inokuma & Satō (1986) wrote: *"You have to train hard so that these three elements will be in harmony with each other when you face your opponent in the judo arena"* (Inokuma & Satō, 1986), interviewee 2 mentioned: *"In Japan, judo embraces something called shin-gi-tai - body, mind, spirit - literally mind, technique, body"*. Judo stands for all of these, something highlighted in this research.

Limitations

The study has a variety of limitations, some of which could not have been expected, such as COVID-19. Language was another of the obstacles that, while being solved, remained a barrier. While the interviews were done with the

help of a skilled interpreter, the researcher would have benefited enormously by being able to speak Japanese directly. In a more open conversation, this would have led to the emergence of new questions. Although the researcher's judo background indicates that Japanese teachers wish to share their expertise and pass it on throughout the world, respondents appeared happy that the questions were targeted rather than a more conversational discussion.

The impossibility of the interviewer and interviewee to be physically present on the mat at the time of the interview, as the researcher had planned, was a second constraint. All of the interviews were conducted online due to COVID-19 constraints. The ability to offer a physical demonstration with many of the questions and answers would be one of the advantages of having both participants physically there rather than online. All Japanese teachers are capable of not only explaining but also demonstrating through examples. One solution to this problem may be to create a list of exercises based on recorded films that show how to establish or enhance rhythm, and this is something that should be thoroughly explored.

The third constraint was travel limitations, which applied not just between Europe and Japan but also to the rest of the globe, preventing the researcher from travelling for an extended period of time and forcing her to postpone scheduled appointments with European specialists. Furthermore, because to COVID-19, admittance to universities was difficult. On a more positive note, where it would normally take months for the researcher to be able to work all the interviews into the experts' usually busy calendar, a reduced workload on their part meant that the interviews could be completed in less than a month. Initially, the researcher designed the research plan whilst based in three *dojo*, across three countries; Sport Wales National Centre (UK), Tokai University (Japan) and Budo Center (Greece). Later, due to COVID-19, when completing the research there was no access to a *dojo*, with the result that the study of specific exercises or even seeing judo in practice was not possible. On the other hand, a big improvement was observed in the study when writing up this work due to the continuous lockdown.

Further research

The author's participation in this study has been a fascinating adventure. However, further research is needed to completely comprehend and analyse rhythm in judo. Extending this study to athletes and coaches appears particularly pertinent, especially in light of the study's findings on the use of rhythm in everyday training. Furthermore, a female teacher replication of this study would be a significant addition to the judo literature.

More qualitative research focusing on elite athletes' training experiences in the context of personal development should supplement the existing findings. This would supplement existing information and contribute to the development of a body of research from which more general conclusions could be drawn. Larger-scale study utilising

diagrammatic analysis could progress this problem area in the future. Future qualitative studies should look into other facets of training that high-level coaches or top athletes may encounter and how they affect their personal growth. According to current research, the advantages of rhythm in athlete development are a longer-term undertaking at every stage. As a result, it appears that quantitative research should at the very least be supplemented with qualitative study.

After the COVID-19 years are through, more research should be done in which a series of workouts at all levels of the athlete's rhythm development, from novice to top athlete, are documented. These activities could be the next step in solving coaches' and athletes' rhythm concerns, as this research demonstrates rhythm development methods.

CONCLUSION

This study offers first-hand accounts from professional teachers of a hitherto unknown phenomena, namely the use of rhythm in judo, and sheds insight on how judo experts understand rhythm in terms of training, competition, and personal growth. To answer the main question, how do high-level judo teachers comprehend the concept of rhythm? These findings suggest that outside of training, coaches play an important role in teaching, mentoring, and leading students.

IPA is an excellent methodology to apply, especially in a topic like judo. *"It's a qualitative investigation into how people make sense of their key life events"* (Charlick et al., 2016). This research looked at how rhythm is used in judo from the perspective of skilled instructors. It has indicated that coaches play a vital role for students, giving instruction, mentoring, and guiding outside of the training context, and has provided important insights into how expert teachers perceive the application of rhythm in judo (Bloom et al., 1998; Jones et al., 2009; Miller et al., 2002).

In judo, this research has both theoretical and practical ramifications. The researcher has been practising judo for 43 years, and his knowledge of the sport influenced his expectations for how and in what way to interpret the results. The researcher's experience can be viewed as a positive quality, and this is in accordance with Columbus and Rice's argument that, in martial arts research, the researcher's familiarity and experiential involvement with the subject area is critical to successful exploration (Columbus & Rice, 1991).

Sport has peculiarities that stem from technical particularities and historical and cultural characteristics, which ultimately affect development in their respective systems and in different environments and countries (Brouwers et al., 2015; Sotiriadou et al., 2014). Judo has its own characteristics, its own standards, and its own culture. Japanese judo is accepted as a model not only because of its results, but also for the way it developed. It is no coincidence that the European Judo Union has as its motto, "Judo - more than sport" (Knaup, 2021).

In conclusion, the research revealed four important points which form the basis of a new method of teaching judo: (1) humans movement, (2) rhythm in judo, (3) technical skills and (4) pedagogical approach.

All stages of a judo practitioner preparation are destined to be applied to the competition, the same applies to the rhythm, "I put this rhythm to use in order to improve my game and, as judo is a combat sport, I always had an awareness of the need to break my opponents' rhythm. I practised keeping both those aspects in mind" (Interviewee 6). After consideration and the findings of this study, leads the researcher to define rhythm in judo as follows.

Therefore, Bountakis definition of rhythm in judo is: The imposition of *tori's* rhythm on the *uke's* movement to create a skilful effective attack with the best use of softness in time and space. Therefore, learning judo requires a pedagogical approach to rhythm in judo.

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Article history

Received: 14 May 2022

Accepted: 15 June 2022

Judo for Peace: More than a Philosophy

By Nicolas Messner, IJF Judo for Peace Director

Abstract: *The main goal of this article is to communicate the philosophy standing behind the “Judo for Peace” activities that have been implemented by the International Judo Federation since 2007.*

Through concrete examples and based on judo principles and values, the “Judo for Peace” director and author highlights how judo impacts the daily lives of thousands of refugees from Turkey, Zambia, South Africa or Malawi.

The “Judo for Peace” programme was launched in 2007. From small scale local projects to global approaches, judo has proven to be effective as a catalyst helping to change perceptions people can have of the world.

Keywords: judo, peace, Judo for Peace, Judo for Children, refugees

BACKGROUND

J We can never repeat enough that judo is more than a sport; it is a philosophy of life with values that are intrinsically linked to its practice. From an early age, it is learned that respecting training partners and opponents in competition is obligatory because without willing partners judo is not possible. It is on the strength of these principles that teachers around the world have, for decades, valued the moral code of judo and transformed it into a concrete application of humanist values. The moral code comprises politeness, courage, sincerity, honour, modesty, respect, self-control and friendship.

Support projects based on judo as a tool for social development are therefore thought of as a natural phase in the practice of our sport. The very essence of this approach is directly linked to the judo mottos offered by Jigoro Kano himself: *seiryoku zenyo* (<http://kodokanjudo.org/en/doctrine/word/seiryoku-zenyo/>), meaning maximum efficient use of energy and especially *jita kyoei* (<http://kodokanjudo.org/en/doctrine/word/jita-kyoei/>), meaning mutual aid and prosperity. It would therefore be deceptive to understand the philosophy underlying the Judo for Peace projects, without perceiving the deep significance of these two ideas, to which it is important to add the notion of 'do,' the path, which characterises the progression of all judoka during their life in judo and which is inscribed in the name of the discipline: JU-DO - the way of flexibility, of adaptation.

In order to analyse work to be undertaken to promote peace in the world, with judo as a basis for discussion and exchange, taking a step back is necessary. In 2007 the International Judo Federation (IJF) included the Judo for Peace Commission as a permanent fixture for the first time, under the leadership of President Marius Vizer. The Commission was established fol-

lowing a proposal from Jan Eirik Schiotz of Norway, who was the “Judo for Peace” director from 2007 to 2014.

An eponymous commission already existed within the European Judo Union, when Mr. Vizer was its president. It was therefore quite logical that the work initiated at the continental level should take on a global dimension as soon as the change of presidency of the IJF took place.

Since 2007 the programmes have continued to expand in three interrelated directions: conflict zones, post-conflict regions and places with social disorders. For each initiative, the words of the founder of judo affirming that “*conflict is to the detriment of all, while harmony is to the benefit of each*,” (Kano, 2007, p.66) resonated and made it possible to set up activities for the benefit of populations, especially the youngest demographics; this is why the “Judo for Peace” Commission also works in close collaboration with the “Judo for Children” Commission, as well as with the commission dealing with development.



Kilis, Turkey, Container City

As Kano also said, "*The idea of considering others as enemies can only be madness and a source of regression*" (<https://sites.google.com/site/citationsport/home/autres-sports/citations-judo/l%E2%80%99ideedeconsidererlesautrescomme-desennemisnepeutetrequedelafolieetunesourcederegression-jigorokano>). It is important to keep in mind that in any form of conflict, those who are in danger the most are also the most vulnerable. Thus, the Judo for Peace programmes focus on youth, without forgetting the other age groups.

Beyond the beautiful ideas that "Judo for Peace" initiatives represent, the IJF always aims to operate via a certain idea of efficiency and results, alongside the humility that must be kept in the face of difficult situations, over which the world of sport has little influence. By this, we mean that while judo is not at the origin of wars and conflicts in the world but of course the sport unfortunately cannot avoid them as such. On the other hand, judo can help alleviate the suffering of the poorest and offer new perspectives, a new vision of a fairer world, as is explained in the United Nations Sport and Peace report, "The purpose of sport for peace initiatives is to harness the power of sport to support the four types of peace-building activities: security, socio-economic foundations, political framework, reconciliation and justice. Sport alone cannot prevent conflict or build peace. However, it can contribute to broader, more comprehensive efforts in a range of important ways." (United Nations General Assembly, 2015). The task is immense, and this is why it is necessary to know how to remain humble, while making every effort to offer opportunities to experience sport-based happiness and support those most affected by conflicts of any kind.



Judo is our right - Malawi, Dzaleka Refugee Camp

Kano pointed out that a person should not be judged by the number of times they fall but by the number of times they get up. "Judo for Peace" programmes can therefore aid recovery when everything else familiar may have been destroyed in the lives of victims of conflict. With this in mind, it is not surprising that one of the major areas favoured is the provision of aid to refugees to promote social cohesion, something that is lacking within communities which fled war zones or those threatened by economic, social and political challenges.

To understand what social cohesion means, why it is crucial in modern society and how sport can play an important role

in reinforcing it, the statement made by Sport and Recreation in the UK is important, "*Social cohesion refers to the bonds that bring society together; it is based on material conditions such as employment, income, health, education and housing, which facilitate good relations between and within communities. These factors form the social fabric of society and indicate social progress. On top of this base comes social order, tolerance and safety, creating a harmonious society. Sport and recreation positively contribute to many of the factors which build social cohesion, such as better physical and mental health, high educational attainment, reducing crime and antisocial behaviour, creating better employment opportunities and earning potential, and ensuring a fit and healthy workforce*" (Sport and Recreation Alliance, 2012).



Ukrainian Refugees

As stated in the Sport For Social Cohesion: Longitudinal Impacts And Challenges study, "*Since the turn of the millennium, the field of sport for development (SFD) has seen an increasing number of non-governmental organisations, government groups and practitioners turning to sport as a means of addressing non-sporting, social development goals*" (Schulenkorf, Sherry, & Rowe, 2016). This is exactly what "Judo for Peace" has been doing for many years, leading with new initiatives, encouraging and facilitating other organisations to be involved to reinforce social cohesion.

"*Each country must adopt the principle of mutual prosperity and conduct its affairs with a firm determination to do everything in its power for the good of all,*" (Kano, 2007, p.78) taught Kano, in the early years of judo. Now, through Judo for Refugees initiatives, the IJF is helping national federations to be part of a global peace process.

CURRENT INITIATIVES

In 2014, in partnership with the Turkish Judo Federation, a first initiative was launched in southern Turkey, in Kilis, where hundreds of thousands of Syrian refugees were transiting or settling after fleeing the civil conflict in their country. Over the years, the Judo for Peace Syria programme grew and adapted to the ever-changing local situation. The first judo sessions were delivered to a few dozen boys in a *dojo* built in containers in a refugee camp on the border. Gradually the programme extended beyond the fences of the camp, in Turkey and then in Syria, offering the possibility for girls to practise as well. By the end of April 2022 more than 2,000 young people had been able to participate. In April 2022 a friendly competition brought together more than 450 young participants from Turkey and Syria and also Azerbaijan, Cyprus and Georgia.

In the run-up to the publication of its 2020 activity reports on cultural and creative industries and sports and development, the 'Agence Française de Développement' (AFD, 2021) underlined the importance of using culture, creative industries, sports and development to nourish social cohesion and complete the fulfilment of achieving their Sustainable Development Goals (SDGs). While the SDGs, also known as the Global Goals, were adopted by the United Nations in 2015, they are a long-term objective, meant to be a universal call to action to end poverty, protect the planet and ensure that by 2030 everyone can enjoy peace and prosperity.

It is with the SDGs in mind that at every step of the "Judo for Peace" programmes, the focus is on dialogue, understanding and mutual respect because as Albert Einstein stated, "*Peace cannot be kept by force. It can only be achieved by understanding*" (Einstein, 1931) It is therefore important that access to the practice of sport takes place with the full understanding of a situation and without any form of discrimination, whether religious, social, ethnic, cultural or gender-based. "Judo for Peace" programmes are designed as platforms from which to enhance social cohesion and learning about differences, which should be seen as strengths rather than weaknesses.

It is interesting to understand why judo, more than any other activity, has the ability to resolve conflicts. For this, it is necessary to read what the founder of the discipline highlighted when he invented judo, basing it on centuries of development of jujutsu in Japan,



Judo For Peace South Africa

"The study of the applications of judo invariably leads to the teaching of seiryoku zenyo, which is the principle behind all honest competition. I have demonstrated that this principle can be applied to everyday life. If we consider our daily activities and social interactions, the teaching of seiryoku zenyo means, for us, to obtain the maximum results by using all the forms of energy at our disposal. It is for this reason that human failings such as anger, for example, violate this principle" (Kano, 2007, p.78).

When the practice of a sport allows the learning of anger management, we can consider that it is of primary importance to teach judo principles from an early age, in order to guard against future conflicts. When conflicts already began, the

principles of the sport can contribute to the relieving of pressure by promoting mutual respect.

"Through a practice that simultaneously integrates martial arts and physical education, it is possible to develop a method that allows you to make a more efficient use of your mental and physical energy. The individual naturally learns how to apply this method to every aspect of life. I consider this basic principle to be an entirely appropriate method to help us resolve the most varied moral questions", said Jigoro Kano (Kano, 2007, p.77).

Those principles were embodied from 1882 onward and throughout Kano's life and they are still the ones underlining all the "Judo for Peace" programmes developed at the international level.

The first refugee camp initiative developed in Turkey served as a model for programmes in Zambia, where today two camps, in Meheba and Mayukwayukwa, host a judo programme. Further programmes thrive in the Dzaleka refugee camp in Malawi (Messner, 2022a) or even more so in South Africa where the IJF has initiated a vast project with a resident coach piloting initiatives for African refugees already living in the country but facing situations of xenophobia or segregation. All "Judo for Peace" actions are developed in close collaboration with their respective national federations. Partnerships are also set up with NGO-type structures, with the private sector and with the United Nations and UNHCR in particular, a Memorandum of Understanding having been signed between UNHCR and the IJF at the beginning of 2022. Progress is constant; in 2017, a first visit of the "Judo for Peace" Commission took place in Jordan, with the possibility of developing a new initiative in the country.

We can say that the principle of *seiryoku zenyo* should be applied every day and at all times. Respecting *seiryoku zenyo* involves acting selflessly for the good of society. This is the reason why, since 2007, while the most visible actions have been for the benefit of refugees, further large-scale initiatives have been carried out in other regions of the world, which may not, at first sight, appear to be facing open conflicts, but where the need for social cohesion remains glaring. Thus, the "Judo for Peace" (JFP) Commission travelled twice to northern Canada, working together with Judo Canada, to work with an Inuit community ravaged by inactivity and the scourges of modern society: alcohol and drugs. This was also the case in Brazil in the favelas of Rio de Janeiro and in Northern Australia, within the Aboriginal community.

The JFP Commission was also present in the south of Argentina, where the city of Rio Grande in Tierra del Fuego declared Judo for Peace a priority, or in the Pacific Ocean in Kiribati and the Solomon Islands where isolated populations face the dangers of climate change. The philosophy of Judo for Peace combined with the principles of Judo for Children, Judo in Schools and Judo for All, makes it possible to create conditions for promoting better living situations by helping national federations to structure themselves around the values of judo. Therefore although many activities are led directly by the IJF and its "Judo for Peace" Commission, a great number of programmes are organised and conducted by the national federations.

rations themselves or by NGOs at a national and local level, contributing to the development of judo on the one hand and to the promotion of a better society on the other.

Whether at the heart of ethnic conflicts ravaging certain countries, such as in the Great Lakes region of Africa, where the Turikumwe (All Together) programme has made it possible to promote values of mutual respect and as such integrate the Judo for Peace projects from 2007, or very recently in the heart of Europe with the war in Ukraine, what guides all Judo for Peace action is the moral code, the values so dear to each judoka.

"I demonstrated that judo is not what most people make of it, that is to say that judo is more than just a combat sport practised inside a dojo. I emphasised that judo carries with it a very different meaning which is fundamental and universal," said Kano (Kano, 2007, p.72).



Judo for Peace in Zambia

He also added that mutual prosperity, *jita kyoei*, arises from mutual assistance and mutual concessions. It is for this reason that when a member of a group helps others and acts selflessly, the group can live in harmony and act as one. In the same way, the group can make better use of its energy as a single man would. This principle remains true even in complex societies, whose populations can number millions of individuals. Thus, if the principles of *seiryoku zenyo* and *jita kyoei* are realised, social life experiences a natural progression and development and each individual, because he is a member of society, can obtain the results he wishes (Kano, 2007, p.66).

With those concepts anchored in our minds, judo can and must allow us to live together in harmony, keeping in mind Kano's idea that *"By practising judo, we understand the true meaning of life through training. You have to develop as a person and become a useful citizen to society"* (Kano, 1882). Judo for Peace works at its humble level to promote peace on the one hand, but also to strengthen the idea of freedom, in the noblest sense of the term, on the other hand.

Judo is therefore a great tool for promoting freedom, that of individuals and consequently, freedom of people. As such, the parallel between the practice on the tatami and its application in life is very interesting. During a judo session, you can indeed decline all forms of freedom of movement and

express all your knowledge in a relationship with another person, which is above all respectful. This is done within a standardised framework, symbolised by the bow at the beginning and at the end of each practice or class; otherwise anarchy could reign. There are few words capable of clarifying the idea conveyed by all "Judo for Peace" projects. Knowing and understanding this, it is not surprising then that as soon as the Ukrainian conflict broke out, it did not take much time or thought to put a structure in place to help the refugees, who within a few weeks became the biggest migration crisis in Europe since the end of the Second World War. The No Borders programme was launched (<https://noborders.ijf.org/>) in April 2022, allowing clubs to volunteer to welcome refugees and both individual and collective initiatives multiplied.

One example saw Sabrina Filzmoser (AUT), former world number one and four-time Olympian, chair of the IJF Athletes' Commission and an IJF Climate Ambassador, travel from sea level to Mount Everest promoting the judo values and spreading a 'No war - Judo for Peace' message. The multi-layered reach of her expedition, including its unwavering message of peace, is one example of the enormous impact even one person can have when carrying the moral code of judo. She said, *"Our Judo For Peace campaign gave me a meaningful understanding of the values our sport stands for and I quickly realised that the goal of my mission should be to support this philosophy. It was received with great enthusiasm and support in both India and Nepal. My thoughts go crazy with simple values such as freedom, peace, equality in society and always definitely friendship, running through my brain."*

Filzmoser's story was not complete at the time of writing but ignited interest from all over the world and inspired young judo athletes from the local area in Nepal but also further afield as many judo clubs responded to her work by initiating their own local environmental projects. The judo community took on the project's full dimension and united around a simple idea: reach out to those who need it, here and now, because that is what Judo for Peace means. Beyond the Judo for Peace programmes themselves, the IJF is directly involved with initiatives that have an impact on global stability and the development of a better world. Following the first participation of refugees at the 2016 Rio Olympic Games, the IJF created its own refugee team, who have been participating in World Judo Tour events and who were present at the Tokyo 2020 Olympic Games (in 2021) and whom even took part in the debut Olympic Mixed Team Event.



Saudi Arabia and Israel competing at the Tokyo Olympic Games

The IJF was very active in promoting dialogue between countries including the Democratic People's Republic of Korea (North) and the Republic of Korea (South), the United Arab Emirates and Israel or the latter and Morocco, to mention a few examples only. This powerful philosophy of peace allowed a match between one athlete from Saudi Arabia and one from Israel during the last Olympic Games, a meeting of these two actions for the first time in a sporting context. *"For both women and for judo, it was an exceptional moment in the world of sport. It was the most socially important moment of the Olympic Games in Tokyo,"* said IJF President Marius Vizer while presenting the Saudi Judo Federation and the Israel Judo Federation with the 2022 Judo for Peace Award.



Judo for Peace in Syria

If the main objective is, therefore, above all educational, with a view to promoting peace and understanding between peoples, the IJF also relies on its world circuit and its world-renowned athletes. Matches take place regularly between athletes from all over the world, during World Judo Tour events, without any kind of discrimination. This contributes to the idea that sport transcends barriers and this is stressed in the Sport and Peace report from the United Nations, *"Sport can be used to create bridges and sustain positive relationships between individuals on opposing sides of a conflict through outreach to participants from these different communities. Research supports the power of sport to create 'relational spaces' across wide and diverse populations. This can take place at the community or elite level"* (United Nations General Assembly, 2015).

In the same report, the United Nations specified that, *"The profile and influence of elite athletes and sporting events can shine a light on the structural causes of social exclusion and help to promote solutions. The global popularity of elite sport makes it an ideal and extremely powerful mass communication platform that can be used to promote a culture of peace. Celebrity athletes, in particular, can be extremely influential as role models and spokespeople for peace and can, when and where appropriate, serve as intermediaries between hostile nations, creating openings for dialogue."*

In the framework of promoting peace, more and more athletes are involved and/or at least show interest in promoting the judo values. Every year the "Judo for Peace" Commission partici-

pates in the April 6 celebrations, which is the International Day for Sport for Development and Peace (Messner, 2020), as it was set up on 23rd August 2013 by the UN General Assembly. This day is commemorated on a global scale each year by international, regional and national sport and development organisations, to honour the role that sport plays in society. It encourages healthier lifestyles, making sport more accessible and using it as a means for development in places populated by vulnerable people, because of conflicts, poverty and inequality. Each year, the number of stakeholders within the judo community and individuals, including top athletes, who are celebrating the IDSDP, increases. The World Judo Day held every year on 28 October, the birthday of Jigoro Kano, is also an important moment to celebrate the judo values in order to reinforce peace (<http://www.worldjudoday.com>).

The same comment can be made for International Women's Day, April 8 Play True Day (IJF, 2022) World Peace Day, International Refugee Day, International Children's Day and any other celebrations that strengthen the dialogue between or within communities (Messner, 2021; Messner 2022b; Messner & Freitas, 2022).

Wilfried Lemke, who was for several years, the Special Advisor to the UN Secretary General on Sport for Development and Peace said that *"sport is indisputably one of the world's most popular leisure activities and it describes a fascinating phenomenon: people from all over the world play, attend, watch, listen to, talk about and experience sport at all levels of performance from amateur to elite. Sport is often described as a language that everyone in the world can understand and indeed sport can bring together and unite groups and communities. On an individual level, sport has the capacity to develop people's skills and faculties. In addition, sport has the power to attract large audiences and can play a major role in communicating positive messages about key issues and assist in driving social change"* (Bennett, 2012).



Judo for Ukrainian Refugees

The examples using sport and specifically judo as a social development tool and life changer to foster peace are numerous. If they seem natural to the vast majority of judo family members because judo is built on a core of strong universal values, we nevertheless have a duty to advocate for a better and more balanced world, when more than ever, our socie-

ties appear to be moving away from this ideal. Beyond Jigoro Kano's ideal, a beautiful and powerful philosophy and some positive words to which it is difficult not to subscribe, "Judo for Peace" activities are intended to be concrete, practical and effective. If sometimes they concern only a small handful of people, their objective is to disseminate a simple idea: it is together, in respect of our differences, that we are the strongest.



IJF Judo for peace Logo

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Article history

Received: 16 May 2022

Accepted: 06 June 2022

Measuring Socio-Emotional Development Resulting From the Practice of Judo, Objectively

By Caio Amaral Gabriel

Abstract: *This research note synthesises a series of studies to propose a theoretical basis to elucidate how to objectively measure the potential development of socio-emotional competence resulting from the practice of judo. It is expected that this proposal can contribute to a step towards the validation of judo as an evidence-based intervention to serve a wide range of contexts, such as health, well-being, education and to promote the cultivation of a more sustainable world through martial arts. This research note is divided into two parts. The first part establishes the association between judo, executive functions, cardiac vagal tone, the central autonomic network, and the development of socio-emotional competence. Based on the association between these aspects, this work proposes the objective measurement of the development of socio-emotional competence resulting from the practice of judo, through the parameters of resting cardiac vagal tone indexed by heart rate variability. The increase in resting cardiac vagal tone optimises executive functioning in terms of inhibitory control and working memory, which studies have shown to have a causal relationship with the development of socio-emotional competence. Then, the second part suggests how judo contributes to a greater resting cardiac vagal tone. Thus, the cardiac vagal tone optimised by judo practice, as indexed by the heart rate variability, can be used as a biomarker to objectively measure the development of students' socio-emotional competence since the increase in resting cardiac vagal tone favours inhibitory control and working memory, the two executive functions that demonstrate a causal relationship with socio-emotional competence.*

Keywords: *judo; executive functions; vagal tone; central autonomic network; socio-emotional competence*

Objective and Relevance

This research note synthesises a series of studies to propose a theoretical basis to elucidate how to objectively measure the potential development of socio-emotional competence as a result of practising judo. It is expected that this proposal can contribute to a step toward the validation of judo as an evidence-based intervention to serve a wide range of contexts (e.g. health, well-being, education, sustainable development).

Theoretical Aspects Behind the Measurement of Socio-Emotional Competence in Judo

This theoretical proposal is based on four aspects: executive functions (EFs), resting cardiac vagal tone (CVT), the central autonomic network (CAN), and the causal relationship between EFs training and the development of socio-emotional competence (SC).

First, the cognitive skills that the founder of judo, Jigoro Kano, in his day, found through observation to be developed through the practice of judo, correspond to the so-called EFs in current neuroscientific literature (Amaral & Gabriel, 2021; see Diamond, 2013; 2012 for details on EFs). EFs are the cognitive skills essential for success in virtually all domains of life, are trainable (Diamond, 2013), support healthy self-regulation

(Hofmann et al., 2012), and the prefrontal cortex is known to be a key structure for efficient executive functioning (Funahashi & Andreau, 2013).

Then, Thayer & Lane (2000) demonstrated the association between EFs and resting CVT: a higher resting CVT is associated with optimisation of executive functioning in terms of two specific EFs: inhibitory control and working memory, so that people with higher resting CVT perform better on EFs-related tasks in a wide range of situations (Thayer et al., 2009).

In summary, the CVT reflects the inhibitory function of the ventral branch of the vagus, the 10th cranial nerve and a main component of the parasympathetic nervous system, on the cardiac sinoatrial node (Porges, 2011). Indeed, CVT is a biological resource associated with numerous health benefits (Kok et al., 2013), which can serve as a promising objective biomarker of mental health (Perna et al., 2019) and which can be objectively measured by some parameters of heart rate variability (HRV; Porges, 2011; Kok et al., 2013). Currently, there are affordable devices capable of measuring HRV validly and reliably (Speer et al., 2020).

So, based on neuroimaging and pharmacological block studies, Thayer et al. (2009) demonstrated a positive association between a greater CVT and an increase in blood flow in different areas of the prefrontal cortex and thus proposed the ability of HRV to index important aspects of prefrontal neural functioning.

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The connection between structures of the central and peripheral branches of the nervous system can be elucidated by the central autonomic network (CAN) (Benarroch, 2008; 1993). Functionally, CAN consists of the brain's control over visceromotor, neuroendocrine and behavioural processes essential for the healthy regulation of the organism. Structurally, the CAN is composed of several structures (see Thayer et al., 2009, p. 142 for details) that are reciprocally interconnected so that energy and information flow bidirectionally from top-down and bottom-up in the central nervous system. The primary output of the CAN is mediated by preganglionic sympathetic and parasympathetic neurons that innervate the heart via the stellate ganglion and the vagus nerve, respectively. The interaction of these elements in the cardiac sinoatrial node produces the complex variability that characterises the heart rate time series. Because of this, Thayer et al. (2009) proposed that CAN output is directly associated with HRV and that HRV is an indicator of central-peripheral neural feedback and integration between the central and peripheral branches of the nervous system.

Finally, Li et al. (2020) demonstrated the causal relationship between inhibitory control and working memory training (the two EFs optimised by increasing resting CVT) and the development of socio-emotional competence.

In this sense, this research note proposes the objective measurement of the development of SC resulting from the practice of judo through the parameters of resting CVT indexed by HRV. The increase in CVT optimises executive functioning in terms of inhibitory control and working memory, contributing to the development of students' SC.

How Judo Can Contribute to a Greater Resting Cardiac Vagal Tone?

Based on the polyvagal theory (Porges, 2011), Gabriel (2021) proposed that judo can be understood as a neural exercise characterised by a hybrid physiological state that involves the dynamic interaction between (1) the inhibitory function of the ventral branch of the vagus nerve over the cardiac sinoatrial node together with other cranial nerves (V, VII, IX, and XI) that constitute the social engagement system (SES), and (2) the sympathetic nervous system, not as a defensive mechanism, as reflected in physiological fight-or-flight states, but as a homeostatic mechanism, in which physical exercise, depending on intensity and duration, favours positive physiological adaptations in the organism (Radak, 2014; Stranahan & Mattson, 2009).

In judo, the SES can be expressed by the concept that developmental psychology calls "rough-and-tumble play" (RTP, i.e. "fighting play"), a modality of social play characterised by elements such as vigorous physical behaviours, physical contact, falls, and positive emotions between the parties involved, and which explicitly differs from actual fighting and aggression (StGeorge & Fletcher, 2020; Cozolino, 2013). In this sense, Blomqvist Mickelsson & Stylin (2021) synthesised a series of studies that help to demonstrate the pro-social aspects invol-

ved in the practice of martial arts and that can stimulate the SES. In turn, as explained by Lucas et al. (2016), physical exercise involves both increasing cardiac output through inhibition of the vagal brake and increasing sympathetic influence on the heart.

So, this dynamic interaction in which the vagal brake is repeatedly inhibited to support physical exercise and then recovered in social engagement behaviours, exercises neural regulation of the autonomic nervous system (Lucas et al., 2016). Over time, physical exercise, positive emotions and positive social connections involved in judo practice, contribute to an upward spiral dynamic characterised by strengthening resting CVT (Kok et al., 2013).

CONCLUSION

This research note proposed (1) the potential mechanisms underlying the increase in resting CVT resulting from judo practice and (2) how the resting CVT optimised by judo practice, as indexed by the HRV, can be used as a biomarker to objectively measure the development of students' SC since the increase in CVT favours inhibitory control and working memory, the two EFs that demonstrate a causal relationship with SC. Thus, this proposal can contribute to new perspectives in which judo can be used as an evidence-based approach for a wide range of contexts. Based on the proposed theory, the "Kyoei Socioemotional Protocol" (KSP) is under development for further validation and potential use by stakeholders.

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Article history

Received: 15 May 2022

Accepted: 23 May 2022

Educating Judo Coaches For Older Practitioners

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Abstract: Older sports practitioners are deemed an ideal model for successful aging. To structure sound training programmes for older individuals, coaches need multi-dimensional education on physiological (body composition, cardiovascular, endocrine, musculoskeletal and pulmonary functions), pathological (single or multiple chronic diseases), psychological (body image, motivation, enjoyment, perception of efforts) and performance (functional fitness, falling skills) aspects of aging. Funded by the European Commission through the Erasmus+ Sport programme, the project “Educating Judo Coaches for Older Practitioners” aims to empower judo coaches with the proper knowledge, skills and attitudes specifically related to the demographic of older individuals. Employing different methodologies for the gathering of evidence, such as literature reviews, focus groups and surveys, the project is benefitting from a combined scientific and experimental practical expertise of team members from educational institutions and judo clubs of seven European countries: Croatia, Italy, Malta, Romania, Slovenia, Spain and Turkey. There is further added value in the collaboration of the education arm of the International Judo Federation through the IJF Academy which has accredited >2000 alumni from 160 countries. Finally, judo partners Judo Club Golovec, Zajednica Sportskih Udruga Grada Rijeke, Liberty Judo Club Oradea, Club de Judo Newton and Izmir Alsancak Gymnastics Specialized Sports Club intend to use and maintain this valuable educational resource, thus contributing to the improved health of the European and international judo community during and beyond the project lifespan.

Keywords: judo; martial arts; combat sports; older individuals; coaches; successful ageing

An Aging World Needs Judo’s Multi-component and Multi-modal Assets

While growing levels of physical inactivity and long life expectancy are present trends in European and high-income countries (European Commission, 2015; 2018), to contrast inactive, lifestyle-related, non-communicable diseases, such as coronary heart disease, diabetes or osteoporosis and to enhance health and quality of life for older individuals, the World Health Organisation recommends a minimum weekly engagement of 150 minutes of moderate intensity aerobic physical activity (PA) or 75 minutes of vigorous intensity aerobic PA or an equivalent combination of moderate and vigorous intensity PA, in addition to muscle-strengthening activities for major muscle groups on two or more days per week. (World Health Organisation,

2015; 2018). Policy makers and stakeholders are urged to support monitoring, surveillance, evaluation and research of PA (World Health Organisation, 2016; 2018). In particular, older individuals engaged in sports are proposed as an ideal model for successful ageing (Capranica et al., 2005; Cortis et al., 2009; Ransdell et al., 2009; Spirduso et al., 2005; Tessitore et al., 2006), shown to contrast the progressive decline of biological functions and decreased functional fitness with advancing age (European Commission, 2015; 2018).

In the literature, martial arts based on movements performed in a slow-motion modality, such as Chinese tai chi and qi-gong, reported positive effects for older individuals (Del-Pino-Casado et al., 2016; Guo et al., 2016; Solloway et al., 2016). Jigoro Kano claimed that “judo is the best form of physical education for all ages” (Kano, 2006). It is estimated that over 40 million judoka practice judo around the world (International Judo Federation, 2019), mainly to improve or maintain satisfactory fitness, competence and appearance, as well as to experience enjoyment and to engage in national and international competitions independently of age, gender, race,

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religion, sexual orientation, competence or disability (Batista et al., 2016; Ciaccioni et al., 2021). It is not only the structure of judo that is based on a progressing scientific understanding (Kano, 1994), but it also combines mental discipline with physical education as a way of life, which fosters a lifelong judo experience. In fact, the International Judo Federation (IJF) organises competitions for youth and senior (range: 15-30 years) age categories, and 5-year veteran age divisions (from >30 to >80 years). To note, in recent years (2016-2019) the veteran world championships has witnessed the participation of a large number of judoka (1014±177) from five continents, the event re-emerging after the forced stop due to the COVID-19 pandemic (International Judo Federation, 2022).

Adapting the multi-component and multi-modal nature of judo to the individual needs and characteristics of the practitioners, while maintaining traditional values and beliefs, as well as self-defence capabilities, judo has been progressively transformed from a form of combat to a sport and to a valuable exercise also in older novice practitioners willing to promote a healthy and active lifestyle. This can improve quality of life in later years and facilitate the maintenance or improvement of anthropometrics and functional fitness, psychological well-being, stability of walking kinematics and the mastering of control during falls (Ciaccioni et al., 2017; 2019; 2020; 2021; Cox, 1993; DelCastillo-Andrés et al., 2018; Kano, 1994; Toronjo-Hornillo et al., 2018). In fact, judo has been proposed as a relatively inexpensive treatment to hinder the decline of functional fitness (Ciaccioni et al., 2019; Ciaccioni et al., 2017; DelCastillo-Andrés et al., 2018), to improve walking performance (Ciaccioni et al., 2021), to counteract a fear of falls and the risk of fall-related injuries (Bu et al., 2010), and to improve physical and mental health by promoting relaxation, self-esteem and mind-body coordination (Burke et al., 2007; Cox, 1993; Woodward, 2009). Judo training sessions usually involve routines comprising stretching, balancing, forms and sparring, a broad range of calisthenics, breakfalls (ukemi) and resistance training (Terry, 2006). While developing balance, control and coordination, the forms (kata) are choreographed patterns of movements combining various defensive and offensive techniques also related to a real fight or self-defence (Cox, 1993), with sparring (randori) practised with a partner and encompassing takedowns, drills, arm locks, choking and grappling (Kano, 1994; Terry, 2006). All these training modalities are widely and effectively used during judo programmes for older practitioners (Ciaccioni et al., 2017; 2019; 2020; 2021; DelCastillo-Andrés et al., 2018; Toronjo-Hornillo et al., 2018). Despite some studies reporting upper extremity injuries in high-level judoka engaging in high-intensity sparring and fighting (Drury et al., 2017; Pocecco et al., 2013; Terry, 2006), no injury has been observed in older novice judo practitioners when trained by judo coaches specialising in this particular population (DelCastillo-Andrés et al., 2018; Ciaccioni et al., 2019). These findings highlight that to obtain health benefits in older practitioners, there is a need for coaches with a thorough understanding of the personal backgrounds and actual conditions of older adults, a solid knowledge of age-related declines, health risks and injury preventions with advancing

age, as well as an openness to adapt judo training principles and techniques to the older novice judoka (European Commission, 2020). Therefore, to develop an effective training programme for older judoka, coaches require multi-dimensional education programmes to include physiological, pathological, psychological and performance aspects of ageing (Spiriduso et al., 2005).

Coach-Centred Educational Programme

In being responsible for the health and safety of sports participants, a lifelong learning approach and continuing education are recommended for coaches (European Commission, 2020). Therefore, the IJF Academy developed blended education programmes, integrating online and on-site lessons and examinations, to ensure high educational standards for judo coaches (<https://academy.ijf.org>). With its motto “ageless judo,” the “Educating Judo Coaches for Older Practitioners project” (EdJCO) has been funded under the European Erasmus+ programme with aims to respect and commit to Kano’s principles by empowering judo coaches with appropriate, functional knowledge, skills and attitudes specifically related to a population of older individuals. EdJCO research encompasses different methodologies for the gathering of evidence and eminence, based on the sound expertise of the team members, experienced through various research work and European projects in the field of sport. The research is being carried out following the Declaration of Helsinki, upon approval of the Institutional Review Board of the University of Rome Foro Italico.

A Team of Academic and Judo Experts

To offer valuable resources to develop, implement and maintain an educational programme targeted at the specific needs of judo coaches in and beyond Europe, the EdJCO think-tank includes the International Judo Federation Academy, judo clubs (Judo Club Golovec, Zajednica Sportskih Udruga Grada Rijeke, Liberty Judo Club Oradea, Club de Judo Newton and Izmir Alsancak Gymnastics Specialized Sports Club) and the University of Rome (coordinator). The project’s outcomes are based on preliminary phases gathering rigorous evidence-based information on judo for older individuals through a systematic literature review and eminence-based knowledge arising from the running of workshops involving judo coaches and scientific experts in sports sciences. Furthermore, judo coaches could co-create a sound education plan for older judoka by participating in a survey to evaluate the relevance of a preliminary list of educational issues to be elaborated on. Indeed, the IJF Academy Foundation, together with the judo clubs involved in the project, play an important role in targeting and recruiting judo coaches and older judoka, in developing the judo-related content of the educational programme, and in informing judo and sports organisations at the local, regional, national and international levels on educational opportunities for coaches of older practitioners.

To raise the awareness of other judo stakeholders, such as coaches and sport managers, regarding the need for specialised knowledge-based coach education, tailored to enhance the health of older individuals through judo, the project partners agreed to synthesise the spirit of the project through a logo encompassing two broken walking sticks symbolising possible anti-ageing effects of a systematic judo pathway, highlighted by the progressive sequence of colours from yellow to the black of the belt (Figure 1). Furthermore, the final project aims will be to integrate, in a co-construction process, the eminence-based knowledge of judo coaches and the evidence-based knowledge of scientific contributions, for the development of a thorough educational programme for the coaches of older judoka. The primary results can be discussed on the project social networks.

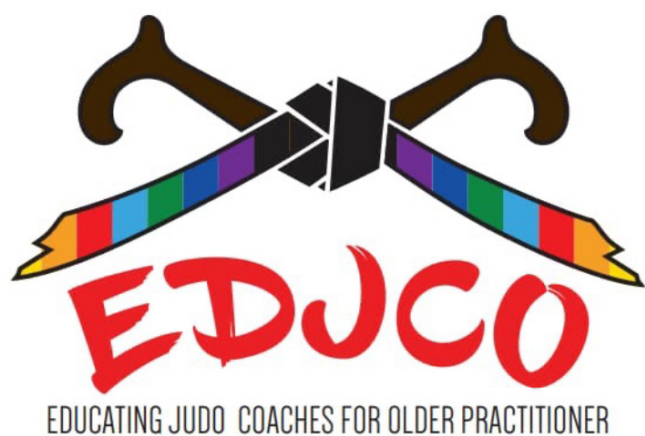


Figure 1. EdJCO logo (the two broken walking sticks symbolize possible anti-age effects resulting from a systematic judo path highlighted by the progressive sequence of colors from yellow to black belt)



Figure 2. An example of a judo lesson for older practitioners (74±4 years old) performing tsugiashi, with hidari shizentai under the supervision of their instructor helping them maintain a right posture, a correct breathing and a relaxed, but concentrated mind

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Article history

Received: 22 March 2022

Accepted: 23 May 2022

The Arts and Sciences of Judo – Authors' Submission Guidelines

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

CONTRIBUTIONS: The ASJ publishes double issues twice per year (June and December) and along with full-length articles (4000-7000 words long) it also publishes shorter items such as research notes and case studies (800-1000 words). Manuscripts are double blind-reviewed and if required are returned to authors for revision and or completion. All manuscripts should be accompanied by abstracts (200-250 words) and by up to six key words.

MANUSCRIPT PREPARATION: Manuscripts should be written in the English language, font 11 Calibri, titles in font 12 and in bold, single spaced in Word format. Please use English UK spelling style that should be consistent within the manuscript. For judo terms please use Dictionary of Judo (Kodokan, 2000).

Please avoid endnotes where possible; unnumbered section headings are preferred. Tables, figures, illustrations and all other supplements should be placed within the text where they are to be printed and also included in a separate file/s. Authors should be consistent when using abbreviations, terminology and referencing. For the layout please check the previous issues of the ASJ journal (tables and graphs).

Two files should be submitted. One file should have only the article title and the other should include the following information on the cover page: title of the article (90 characters maximum), name of author(s), academic attainment and complete address (telephone and e-mail address). The editor will return the paper to the author(s) if not following all manuscript preparation guidelines.

REFERENCES: In the text and in the reference list, references should be cited using APA style (<http://www.apastyle.org>).

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