Strength and conditioning (S&C) practices of judo athletes and S&C coaches: a survey-based investigation

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STRENGTH AND CONDITIONING (S&C) PRACTICES OF JUDO ATHLETES AND S&C COACHES: A SURVEY-BASED INVESTIGATION

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ABSTRACT

The benefits of strength and conditioning (S&C) for improving judo performance and reducing injuries have been widely studied. However, the S&C practices employed and perspectives held by those delivering S&C have yet to be elucidated. Therefore, this study investigated the S&C practices and perspectives of judokas and S&C coaches working within judo. Forty-two judokas and nine S&C coaches completed an online survey comprising six sections: (a) written informed consent; (b) background information; (c) education, qualifications, and prescription; (d) views on S&C; (e) exercise selection; and (f) issues and improvements. Frequency analysis was used to report responses to fixed-response questions, and thematic analysis for open-ended questions. Results indicated that S&C coaches were primarily responsible for delivering S&C programs (60%), and S&C information was predominantly sourced from S&C coaches (43%). Strength and conditioning was deemed *very important* for *randori* (78-88%), overall judo-performance (67-79%), and judo-fitness (62-78%). Similarly, S&C was considered *very important* for the development of speed and power (76-89%), strength (71-89%), and injury reduction (69-78%). Novel findings were also observed, such as integrating judo-specific training within S&C practice, which may be partly explained by more S&C coaches holding judo belts (67%) than S&C qualifications (11%). This study supports practitioners delivering S&C in judo by offering a base of information to critique or align with their existing S&C practices and perspectives. Furthermore, our results may help identify potential gaps between methods used, proposed guidelines, and actual practice, facilitating the development of research and education resources tailored to the current climate.

Key Words: survey; exercise selection; physical development; programming; physical testing.

Introduction

Judo is a combat sport contested at the Olympic and Paralympic Games since 1964 and 1988, respectively. Judo participation continues to grow with an increased number of judokas competing in high-level competitions (e.g., world judo events) (37). Successful judokas demonstrate superior technical and tactical skills, including grips (i.e., kumi-kata), feints, and transition to groundwork (21,35,38,53), and can repeat such skills over a competition (48). These demands have increased due to rule changes whereby a 4-minute match can be extended indefinitely until a winner prevails (35). To support these extensive physical demands, judokas should possess well-adapted physiological (19), physical (36), neuromuscular (14), and psychological (69) attributes.

Activity-to-recovery ratios in competitive judo matches range from 2:1 to 3:1, which requires judokas to possess a large aerobic capacity to recover from repetitive high-intensity actions (48,50). This is further explained by the energy system requirements during competitive judo matches, including 70% contribution via the oxidative system, 21% from ATP-PCr, and 8% via anaerobic glycolysis (32). Other important attributes such as handgrip strength and endurance, lower limb force production (39,41), and ability to sustain critical velocity (22) underpin the repetitive execution of technical actions (e.g., grips, feints, throws) (48). Research has shown that ~50% of effective attacks performed in official judo competitions were related to judokas' performance in physical tests (e.g., handgrip strength and countermovement jump) (36). Therefore, developing the aforementioned attributes via strength and conditioning training (S&C) may give judokas a competitive advantage.

Judokas who experience consistently large spikes in training and competition loads are more susceptible to fatigue and are exposed to situations that may cause injury (e.g., being involved in or defending powerful throwing techniques) (4,11,40). Given the importance of injury reduction to judokas, this topic has been widely studied (4,49,55). Longitudinal data between 2005-2020 highlighted that 28,297 top European judokas across 128 competitions registered 699 injuries (4). Of these injuries, the most common sites included the knee (17%), shoulder (16%), and elbow (14%), with the most frequently reported injuries being sprains (42%) and contusions (23%) (4). Various methods are suggested to reduce injury occurrence among judokas, such as rule changes, technique improvement, and physical development/preparation (55). Accordingly, specific injury prevention programs have been created, focusing on the

physical preparation of judokas, such as the IPPON warm-up program (24). This program includes exercises that improve flexibility, agility, balance, coordination, strength, and stability, which are considered essential for judo performance and injury reduction (24).

To prepare judokas for the demands of competition and reduce injury occurrence, there is a need for the wider support team (e.g., judo coaches, S&C coaches, and physiotherapists) to work cohesively (57). A key member of this team is the S&C coach, who uses assessments to test the physical performance (38) and potential injury risk (24,46) of judokas. Hereafter, the S&C coach can use testing data, amongst other methods, to design, monitor, and evaluate training programs (3,10,45,58) to help judokas maintain and maximize their physical capabilities (47). To inform the practices of S&C coaches, considering the perspectives of sports coaches and athletes may help optimize the efficacy and adherence to S&C training programs and foster stronger relationships (57,60,66,67).

Accordingly, a growing body of research has emerged investigating the S&C practices and perspectives of athletes and S&C coaches across different sports (e.g., soccer, cricket, rugby, track and field) (43,44,65–68). This research is important, as it helps identify the utilization of contemporary S&C practices and establish whether these align with S&C guidelines and research or if alternative and anecdotal methods are preferred. The consensus amongst these studies is the critical role S&C plays in the physical development of athletes, which can underpin the performance of sports-specific actions and reduce injury risk. However, there is limited evidence on this topic area in combat sports beyond wrestling (30). Consequently, it is uncertain what S&C practices are employed in other combat sports, such as judo. This requires further investigation, given the potential importance of S&C for various physical and physiological factors associated with superior judo performance, as highlighted previously (e.g., strength, power, speed, and injury reduction) (22,24,39–41). Therefore, the present study investigated the S&C practices and perspectives of judokas and S&C coaches working within the sport. The results of this investigation may help identify potential gaps between methods used, proposed guidelines, and actual practice, facilitating the development of research and education resources tailored to the current climate.

Table 1. Definitions of judo terminology.

Term	Definition
Harai-goshi	Hip throw technique
Kumi-kata	Fighting grips
Kuzushi	Breaking opponents balance
Morote-seoi-nage	Shoulder throw technique
Nage-Komi	Repetitive throwing
Ne-Waza	Groundwork fighting
O-soto-gari	Foot throw technique
Ouchi-gari	Foot throw technique
Randori	Free Fighting
Sasae-tsurikomi-ashi	Foot throw technique
Uchikomi	Repetition training

Methods

Experimental Approach to the Problem

This cross-sectional survey study investigated the S&C practices and perspectives of judokas and S&C coaches from different countries and levels.

Subjects

Forty-two judokas (n = 32 male, n = 9 female, n = 1 non-disclosed; age: 29 ± 10 yrs, range: 18 to 61 yrs) and nine S&C coaches (n = 9 male; age: 39.6 ± 9.4 yrs, range: 27 to 54 yrs) participated in this study.

Procedure

The anonymous online surveys used in this study were adapted from prior research across various sports (44,65,68) and developed using the survey application Google Forms (Alphabet Inc, USA). The surveys designed in the above studies underwent pilot testing with experienced researchers, practitioners (e.g., S&C coaches, sports coaches), and athletes to assess for content validity. For this study, surveys were initially written in English and translated into Portuguese. Hereafter, the survey's content validity was evaluated by each research team member, three judokas, and three S&C coaches through pilot testing before being finalized. This led to minor changes in some questions' wording and structure to ensure they were clear and appropriate for the surveyed population. Six sections were included in the surveys, (a) written informed consent; (b) background information; (c) education, qualifications, and prescription; (d) views on S&C; (e) exercise selection; and (f) issues and improvements. Both (judoka and S&C coach) surveys included 13 fixed responses and 12 open-ended questions (see appendix).

A digital invitation letter was emailed to prospective participants through various channels to access the surveys (e.g., judo governing bodies and professional networks). The

surveys detailed the inclusion criteria, purpose, aims, required time commitment, and confidentiality of responses, to help participants provide consent. The inclusion criteria for judokas were: (a) 18 years of age or above, (b) currently competing in competitive standard judo, and (c) currently involved in an S&C program. For S&C coaches, the inclusion criteria were: (a) 18 years of age or above, (b) currently working in competitive-standard judo, and (c) currently prescribing S&C programs to competitive-standard judokas. The Human Subjects Ethics Sub-Committee of ***REMOVED FOR PEER REVIEW*** approved this study, which was conducted per the Declaration of Helsinki.

Statistical Analyses

All survey responses were downloaded into a Microsoft Excel Spreadsheet (version 16.68, USA). Fixed-response questions were assessed using frequency analysis. Open-ended response questions were initially evaluated by the lead author following a six-stage thematic analysis process, (a) familiarization with the data; (b) generating initial codes; (c) searching for themes; (d) reviewing themes; (e) defining and naming themes; and (f) producing the report (6,7). Hereafter, each theme and pattern emerging from the raw data were discussed, reviewed, and agreed upon by all co-authors who have extensive experience as practitioners and athletes in judo and other combat sports. This thematic analysis method has been used in prior studies surveying sports coaches, athletes, and S&C coaches (27,56,64,67).

Results

Participant Geolocation and Experience

Judoka participants were geographically based in Brazil (50%), the United Kingdom (24%), Spain (7%), Hong Kong (SAR China), Japan, Australia, India, Canada, Haiti, Zambia, and Ethiopia (all 2%). S&C coaches were located in Brazil (67%), the United Kingdom (22%), and Serbia (11%). Participants' experience working in judo was 15 ± 9.5 yrs (range: 1 to 50 yrs) for judokas and 15.2 ± 12.3 yrs (range: 4 to 35 yrs) for S&C coaches. Judokas self-reported competition standards were international (38%), national (45%), regional (5%), state (7%), and municipal (2%). Strength and conditioning coaches provided support to judokas at international (56%), national (33%), and state (11%) standards.

Education, Qualifications, and Prescription

Judokas' highest levels of education were bachelor's degree (55%), secondary school (21%), master's degree (12%), higher diploma/associate degree (7%), and Doctor of Philosophy (Ph.D.) (5%), with 41% of qualifications in sports or physical education-related fields. S&C coaches highest levels of education were bachelor's degree (44%), master's degree (33%), and Ph.D. (22%), with 100% of qualifications in sports or physical education-related fields. Qualifications in S&C were held by 9% of judokas, with the National Strength and Conditioning Association (NSCA) (7%), and Australian Strength and Conditioning Association (ASCA) (2%), respectively. Only 11% of S&C coaches held S&C qualifications and were based in the United Kingdom and accredited by the United Kingdom Strength and Conditioning Association (UKSCA). The judo belts held by judokas were brown (43%), black 1st dan (26%), black 2nd dan (10%), black 3rd dan (7%), black 5th dan (5%), and coral 6th dan, black 4th dan, orange, and blue (all 2%). The judo belts held by 67% of S&C coaches were black 4th dan (33%), black 2nd dan (22%), and black 3rd dan (11%).

According to judokas, S&C coaches (60%) were primarily responsible for prescribing S&C programs, and to a less extent by head coaches (21%), independently by judokas (12%), and trainers (7%). Besides their programming, S&C coaches reported that the other personnel responsible for prescribing S&C programs were head coaches (78%), and independently by judokas and trainers (both 11%). The percentage of judokas and S&C coaches reporting where they predominantly sourced S&C information is presented in Figure 1.

Views on Strength and Conditioning

The perceptions of judokas and S&C coaches regarding the importance of S&C for different judo and physical components are presented in Figures 2 and 3, respectively.

Overall, when asked how effective their S&C training programs were, judokas reported moderately effective (31%), very effective (26%), effective (26%), slightly effective (14%), and not effective (2%). Whereas S&C coaches reported mostly effective (44%), very effective (33%), and moderately effective (22%). Exemplar responses are provided below.

> Judoka (positive), *"An increase in strength, power, and endurance that can be seen in judo performance. Lower injury rate and quicker return to play after injury"* and *"After*

specific strength training for judo, I felt a big difference in technical/randori training, especially in kumi-kata".

Judoka (constructive), *"My coaches and fellow athletes have a limited understanding of S&C", "Lacking consistency of S&C training"*, and *"Limited access to resources".*

S&C coach (positive), *"S&C is well incorporated into my athlete's annual training plan, including skill training and the International Judo Federation (IJF) competition system"* and *"S&C is extremely important for our competitive athletes, conditioning accounts for about 50% of the total preparation time for competition".*

S&C coach (constructive), *"Time is limited as is monitoring load"* and *"Could be more effective if we had a better infrastructure".*

Judokas and S&C coaches described their views on S&C for judo, with exemplar responses provided below.

Judoka (positive), "*It is now mandatory for judokas to undertake S&C and be physically prepared to win in high-level judo competition and remain injury free*" and *"S&C is often underutilized. It improves speed, power, agility, and conditioning, which allows for higher quality technical practice and better execution of techniques".*

Judoka (constructive), *"Unfortunately, there is a severe lack of understanding and education around S&C in judo at a grassroots level"* and *"Few technicians know how to prescribe S&C training for judo. They try to apply new things in their dojos by reproducing what they see, but without knowing why or reflecting on their practice".*

S&C coach (positive), *"You cannot perform in judo without specific physical training. At the highest level, the ability to produce and sustain force is one of the main predictors of success"* and *"Many of the characteristics and actions required for judo can be developed during S&C practice"*.

S&C coach (constructive), *"The challenge is balancing mat-based load with S&C training"* and *"S&C is widespread, but there are limited resources for its application".*

Exercise Selection and Preferences

The exercise preferences of judokas and S&C coaches for different areas related to judo performance are presented in Table 2, with exemplar responses for the highest-ranked exercises provided below.

Strength (deadlift)

Judoka, *"It is a whole body exercise, which covers the muscles used for throwing".*

S&C coach, *"A very complete exercise that can be modified to focus on different areas of strength, including the grip and posterior chain".*

Speed and Power (weightlifting):

Judoka, *"Is a total body exercise and is great for developing rate of force production".*

S&C coach, *"The movement of hip extension and transfer of force is important for judokas and has similarities with the extension occurring in throwing".*

Agility (judo-specific movements):

Judoka, *"Banded uchikomi is highly specific, allowing the judoka to move explosively in the pattern of the throw being practiced".*

S&C coach, *"Specific transfer to judo techniques".*

Judo-specific fitness (judo-specific movements):

Judoka, *"Tabata uchikomi drill"*

S&C coach, *"Mat-based conditioning"*.

Judo-Specific Injury Reduction: differences were observed between judokas and S&C coaches for the most important exercise. Judokas presented a broad range of responses falling into the

miscellaneous category, which included *"Elastic band exercises"* and *"A good warm-up"*. Whereas the most important exercises reported by S&C coaches were categorized into general strength, which included *"Eccentric strength exercises"* and *"Turkish get up"*.

Issues and Improvements

Perceived issues, disadvantages, desired improvements, and future developments regarding the S&C of judokas and S&C coaches in judo are presented in Table 3.

Table 2. Preferred exercises of judokas (n = 42) and strength and conditioning coaches (n = 9) for different areas related to judo performance.

Area	Rank	Exercise		1st Most Important Exercise (%)	2nd Most Important Exercise (%)	3rd Most Important Exercise (%)
Strength	1	Deadlift and Variations	Judoka	**24**	5	7
			S&C Coach	**56**	11	0
	2	Squat and Variations	Judoka	21	14	**19**
			S&C Coach	11	33	**22**
	3	Bench Press (including push-ups)	Judoka	17	**29**	17
			S&C Coach	11	11	**22**
	4	Rowing (e.g., barbell)	Judoka	12	7	12
			S&C Coach	11	0	**22**
	5	Weightlifting and Derivatives	Judoka	12	10	5
			S&C Coach	0	0	0
	6	Pull-up	Judoka	7	7	5
			S&C Coach	11	**44**	11
	7	Miscellaneous (e.g., specific strength training)	Judoka	5	14	17
			S&C Coach	0	0	11
	8	Judo-Specific Movement	Judoka	2	2	0
			S&C Coach	0	0	11
	9	No Answer	Judoka	0	7	7
			S&C Coach	0	0	0
	10	Core (e.g., Russian twist)	Judoka	0	2	7
			S&C Coach	0	0	0
	11	Plyometrics (e.g., single-leg hop)	Judoka	0	2	5
			S&C Coach	0	0	0

Speed and Power	1	Weightlifting and Derivatives	Judoka	**21**	19	14
			S&C Coach	**78**	**56**	11
	2	Judo-Specific Movement	Judoka	**21**	7	5
			S&C Coach	0	0	11
	3	Sprint	Judoka	14	5	2
			S&C Coach	11	0	0
	4	Plyometrics (e.g., box jump)	Judoka	12	7	10
			S&C Coach	11	22	22
	5	Miscellaneous (e.g., circuit exercises)	Judoka	10	14	14
			S&C Coach	0	22	0
	6	Rowing (e.g., barbell)	Judoka	5	5	2
			S&C Coach	0	0	0
	7	Deadlift and Variations	Judoka	5	2	0
			S&C Coach	0	0	11
	8	Ballistics (e.g., medicine ball throw)	Judoka	5	0	5
			S&C Coach	0	0	**44**
	9	Squat and Variations	Judoka	2	7	5
			S&C Coach	0	0	0
	10	Bench Press (including push-ups)	Judoka	2	2	5
			S&C Coach	0	0	0
	11	Pull-up	Judoka	2	2	0
			S&C Coach	0	0	0
	12	No Answer	Judoka	0	**29**	**38**
			S&C Coach	0	0	0
Agility	1	Judo-Specific Movement	Judoka	**29**	0	0

			S&C Coach	**44**	22	11
	2	Coordination (e.g., foot, hand, eye)	Judoka	19	14	5
			S&C Coach	0	0	11
	3	Plyometrics (e.g., horizontal jump)	Judoka	12	10	10
			S&C Coach	33	**33**	**44**
	4	Sprint	Judoka	12	2	5
			S&C Coach	0	11	0
	5	Miscellaneous (e.g., resistance band exercise)	Judoka	12	5	2
			S&C Coach	0	0	0
	6	No Answer	Judoka	7	57	69
			S&C Coach	0	**22**	**22**
	7	Weightlifting and Derivatives	Judoka	5	2	0
			S&C Coach	0	0	0
	8	Change of direction (e.g., 505)	Judoka	2	7	2
			S&C Coach	22	11	11
	9	Strength (e.g., lateral lunge)	Judoka	2	2	7
			S&C Coach	0	0	0
Judo-Specific Injury Reduction	1	Miscellaneous	Judoka	**21**	12	10
			S&C Coach	11	11	0
	2	Hamstring Curl (e.g., Nordic hamstring curl)	Judoka	17	10	10
			S&C Coach	0	0	0
	3	No Answer	Judoka	12	**31**	**52**
			S&C Coach	0	0	0
	4	Squat and Variations	Judoka	12	7	0
			S&C Coach	22	11	11

	5	Strength – General	Judoka	12	0	0
			S&C Coach	**33**	11	11
	6	Stretching/Mobility	Judoka	10	0	0
			S&C Coach	0	22	11
	7	Balance/Proprioception (e.g., single leg balance)	Judoka	7	17	2
			S&C Coach	0	0	22
	8	Core (e.g., plank)	Judoka	5	2	0
			S&C Coach	11	11	22
	9	Judo-Specific Movement	Judoka	5	0	5
			S&C Coach	0	0	0
	10	Strength - Shoulder (e.g., external rotation)	Judoka	0	10	7
			S&C Coach	11	0	22
	11	Deadlift and Variations	Judoka	0	5	0
			S&C Coach	11	33	0
	12	Strength - Isolation (e.g., neck)	Judoka	0	2	7
			S&C Coach	0	0	0
	13	Bench Press (including push-ups)	Judoka	0	2	5
			S&C Coach	0	0	0
	14	Weightlifting and Derivatives	Judoka	0	2	2
			S&C Coach	0	0	0
Judo-Specific Fitness	1	Judo-Specific Movement	Judoka	**43**	26	26
			S&C Coach	**56**	**33**	11
	2	No Answer	Judoka	10	**38**	**38**
			S&C Coach	0	11	22
	3	Grip (e.g., judogi pull-up)	Judoka	10	2	2

4	Sprint	S&C Coach	0	0	0
		Judoka	14	2	5
		S&C Coach	0	0	11
5	Miscellaneous (e.g., Wingate)	Judoka	7	19	12
		S&C Coach	22	22	**33**
6	Plyometrics (e.g., squat jump)	Judoka	5	5	5
		S&C Coach	0	11	11
7	Ballistics (e.g., kettlebell swing)	Judoka	5	2	0
		S&C Coach	0	0	0
8	Circuit Training	Judoka	2	2	5
		S&C Coach	22	11	0
9	Squat and Variations	Judoka	2	2	2
		S&C Coach	0	0	0
10	Bench Press (including push-ups)	Judoka	2	0	5
		S&C Coach	0	11	11

Numbers in bold indicate the most common response.

Note: S&C: strength and conditioning.

Table 3. Judokas (n = 42) and strength and conditioning coaches (n = 9) responses to their perceived issues, disadvantages, desired improvements, and future developments regarding strength and conditioning in judo.

	Rank	Theme	Exemplar Response	Judoka (%)	S&C Coach (%)
Issues	1	Periodization	"Difficult to strike a balance between S&C and judo practice"	**19**	**44**
	2	Fatigue	"Athletes present a lot of fatigue and micro-injuries after judo training"	**19**	11
	3	Insufficient Time	"When combined with randori and travel, time management is an issue"	14	22
	4	Facilities/Resources	"Lack of specific equipment"	10	0
	5	No Answer		12	0
	6	Injury	"Coming back from a bilateral shoulder injury, I feel some restriction in movement"	10	0
	7	Technical Understanding of S&C	"Athletes are unfamiliar with basic exercises"	7	11
	8	Motivation	"How to stimulate and motivate the athlete within the S&C training period"	7	11
	9	Miscellaneous	"Weight gain"	2	0
Disadvantages	1	No Disadvantages	"I think there are no downsides to S&C"	**21**	11
	2	Fatigue	"If not programmed correctly it can lead to an accumulation of fatigue and increase the likelihood of injury"	19	0
	3	Injury	"Injuries may occur when exercises are not performed well or not enough rest time"	17	11
	4	Non Judo-Specific	"When you train with barbells, you become a barbell. It's difficult to train	12	11

			reactive strength when the bar is solid and doesn't move unpredictably like a human"		
	5	Insufficient Time	"Leads to less time to do judo"	7	0
	6	Technical Understanding of S&C	"Not knowing how much weight you can lift without an S&C coach present all the time"	7	0
	7	Miscellaneous	"Lack of funds"	7	11
	8	Weight Reduction	"Gaining muscle mass can take the athlete over the weight limit for their category"	7	11
	9	Periodization	"Balance of load from mat-based training, travel, and competition	2	**44**
Improvements	1	Periodization	"More regular communication to identify fatigue levels and progress or regress exercises accordingly"	**24**	**44**
	2	Miscellaneous	"More S&C coaches, more resources, and more continued professional development for S&C coaches in combat sport"	21	11
	3	Increased Number of S&C Sessions	"More sessions, so I can lift in the morning and do judo practice at night. Off days would be weekends, where I can do light cardio and mobility"	17	0
	4	Judo-Specific S&C Movements/Equipment	"I would develop updated judo tests and create ergonomically designed machines to execute judo-specific movements"	12	33

	5	Athlete Education	"More theoretical training for athletes, to raise awareness of the importance of strength training and its correct application"	10	0
	6	Greater Focus - Agility	"Set more agility training to improve my area of weakness"	5	0
	7	Greater Focus - Strength	"More time to train strength"	7	0
	8	Technology Integration	"I would use technology to help with training"	2	11
	9	No Answer		2	0
Future	1	Judo-Specific S&C Training	"A United Kingdom based group looking specifically at S&C in combat sport (judo)"	**26**	**33**
	2	No Answer		21	11
	3	Miscellaneous	"Improved diet and supplementation"	17	22
	4	Greater Focus - Strength Training	"More strength training"	10	0
	5	Athlete Education	"Provide videos and resources for judo S&C"	7	0
	6	Greater Focus - Fitness Training	"Integrate high-intensity interval training"	5	0
	7	Technology Integration	"Platforms, sensors, and technological devices where results are reliable and extracted in real time"	5	**33**
	8	Greater Focus - Power Training	"More explosive type training"	5	0
	9	Greater Focus - Agility Training	"Increased agility training"	2	0
	10	Greater Focus - Flexibility Training	"More flexibility to reduce injuries"	2	0

303 Numbers in bold indicate the most common response.

304 Note: S&C: strength and conditioning

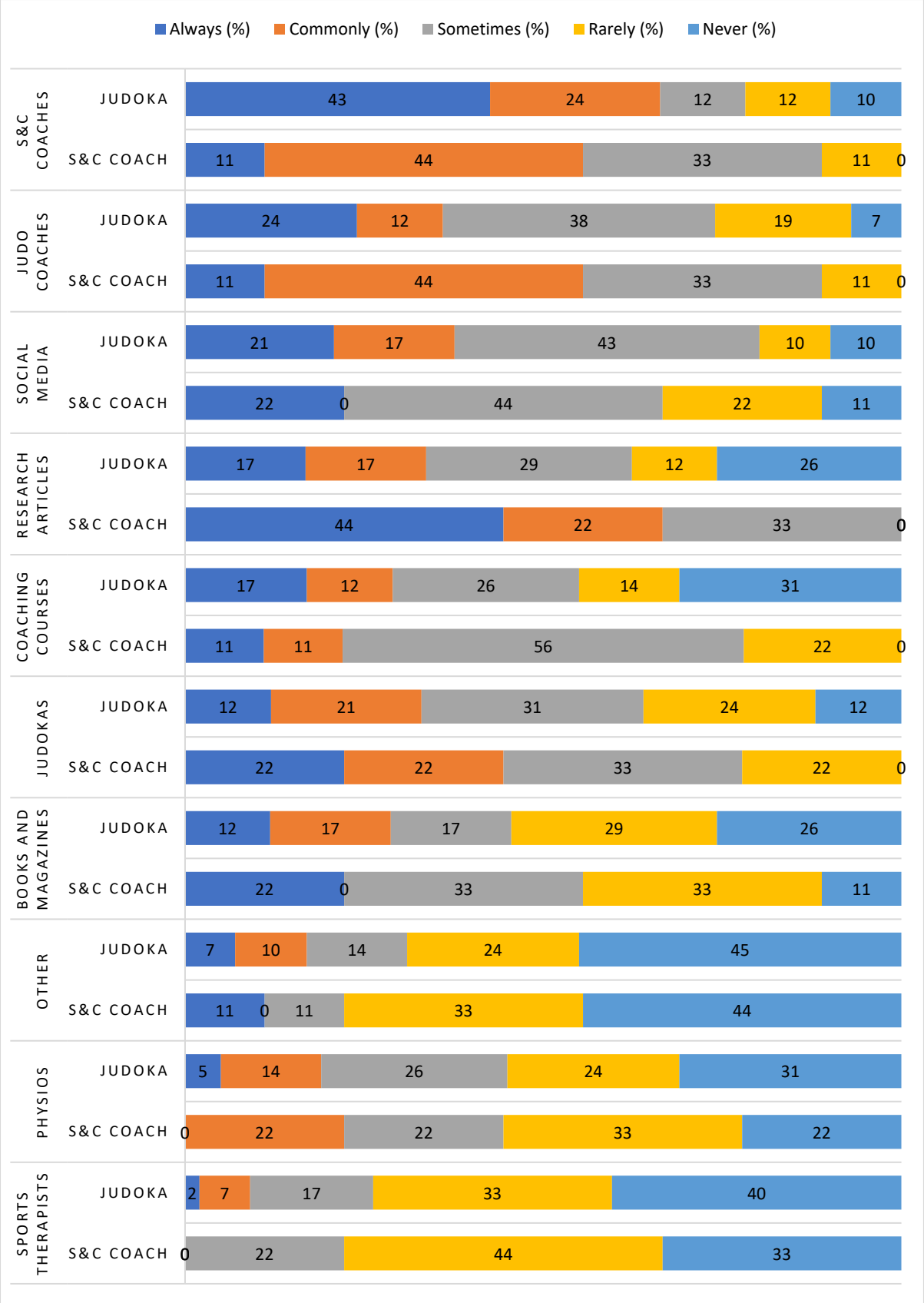

Figure 1. Where judokas (n = 42) and strength and conditioning coaches (n = 9) predominantly source strength and conditioning information.

Note: S&C: strength and conditioning, Physios: physiotherapists.

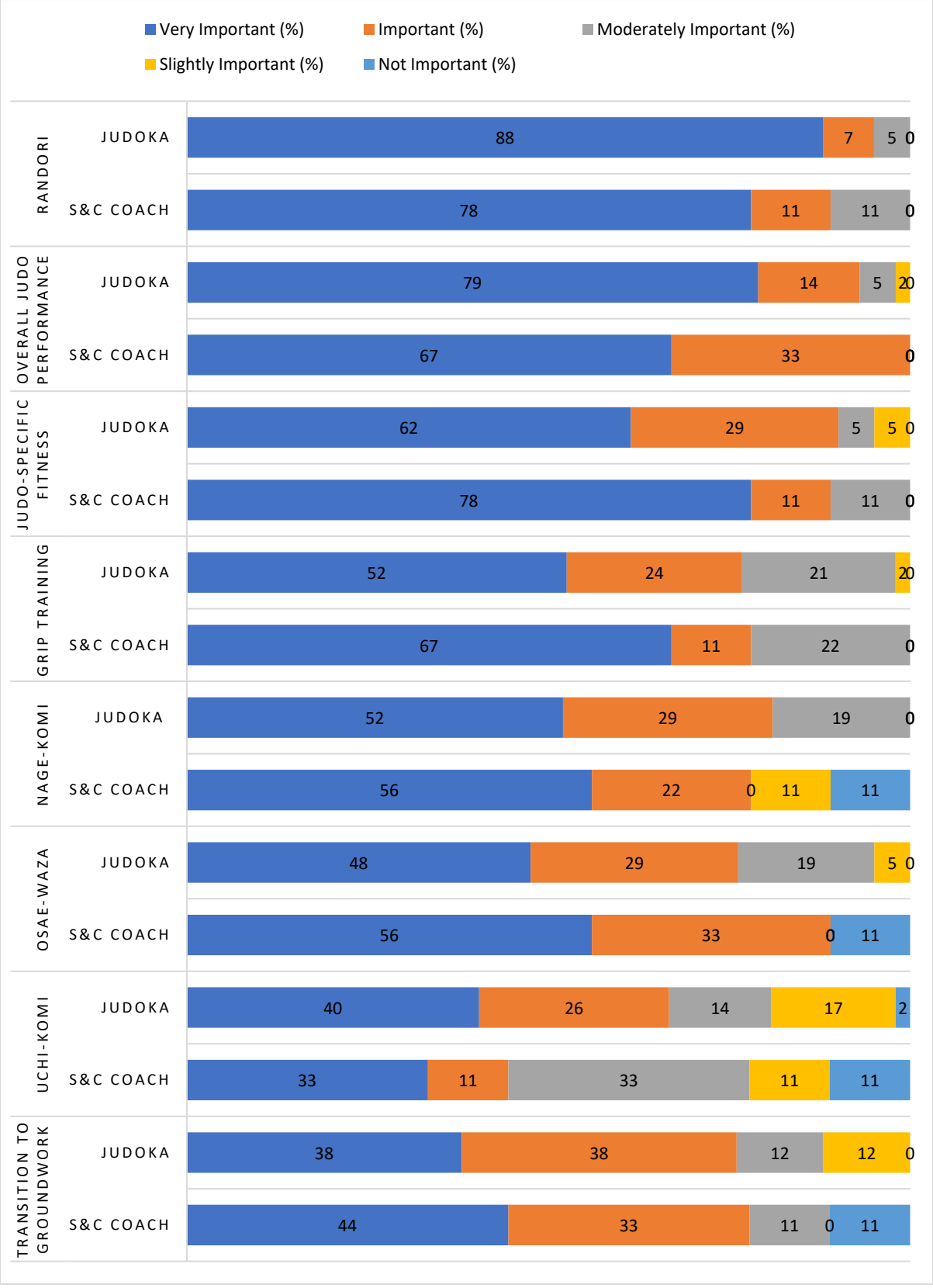

Figure 2. Judokas (n = 42) and strength and conditioning coaches (n = 9) perceptions of the importance of strength and conditioning for different areas of judo.

Note: S&C: strength and conditioning, Randori: combat or fight practice, Nage-Komi: repetitive throwing training, Osae-Waza: hold down training, Uchi-Komi: repetitive technical training.

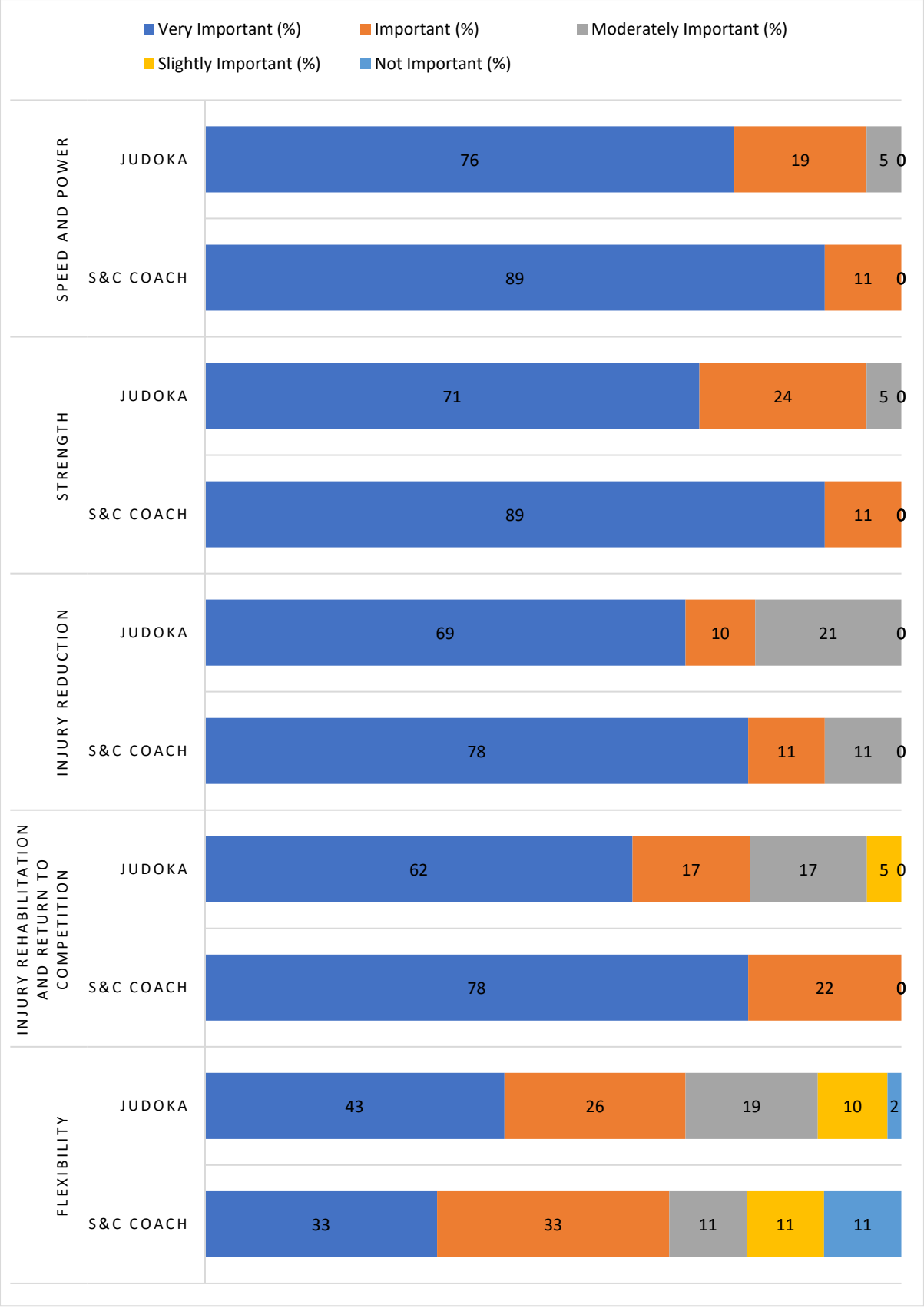

Figure 3. Judokas (n = 42) and strength and conditioning coaches (n = 9) perceptions of the importance of strength and conditioning for different physical components.

Note: S&C: strength and conditioning

Discussion

This survey study aimed to investigate and provide original evidence on the S&C practices and perspectives of judokas and S&C coaches working within judo. Results indicated that S&C coaches were primarily responsible for delivering S&C programs and that S&C information was commonly sourced from S&C coaches and research articles, despite few S&C coaches holding S&C qualifications. Strength and conditioning was deemed *important* to *very important* for a range of judo-specific skills and physical abilities. Preferred exercises for different areas associated with judo performance generally aligned with research recommendations. However, novel and interesting findings were also found, possibly associated with the unique nature of judo training and competition and the limited research on this topic in judo and other combat sports. The information presented in this study can support those working in judo by offering a base of knowledge to critique or align their existing S&C practices. Furthermore, it may direct future research concerning S&C in judo and inform governing bodies' recommendations for professional practice, education, and qualifications.

A key finding was that despite the importance placed on S&C for developing physical and technical judo-related abilities (see Figures 2 and 3), only ~10% of all participants held S&C qualifications. However, 100% of judokas and 67% of S&C coaches held judo belts, and >80% had competed/worked in national-standard judo competitions and above. Accordingly, within S&C training, judo-specific movements were extensively prescribed (see Table 2). Our findings are in contrast to other sports where S&C coaches more commonly held S&C qualifications, such as cricket (76%) (64), soccer (65%) (63), swimming (58%) (13), and rugby union (56%) (31). Additionally, the possession of sport-specific qualifications of S&C coaches in judo was greater (67%) than that reported by S&C coaches in soccer (54%) (63) and cricket (40%) (64). Therefore, this may indicate that judokas and judo-based S&C coaches may emphasize the transfer of physical development to the technical-tactical components of performance.

Judokas reported that S&C programs were prescribed mainly by S&C coaches (60%), but this still indicates that 40% of programs are delivered independently or by the wider support team. However, it appears a larger proportion of S&C programs are delivered by S&C coaches in judo when compared to data reported by soccer (40%) and volleyball (47%) athletes in Hong Kong (66,67). It is widely recommended by organizations such as the NSCA that those

responsible for delivering S&C should hold relevant certifications through an accredited S&C program (e.g., NSCA Certified Strength and Conditioning Specialist [CSCS]) to reduce the risk of liability when supervising or instructing S&C sessions (59). However, a recent analysis of job descriptions (n = 50) across five countries (United Kingdom, United States of America, China, Singapore, and New Zealand) revealed that less than 50% of employers were seeking applicants with S&C certifications (62). Within this study, only 26% of judokas reported their S&C programs to be *very effective*, which could be related to the limited number of qualified S&C coaches delivering programs. However, responses regarding the inefficacy of programs were broad-ranging and included *"lacking consistency of S&C training"*, *"access to resources",* and *"time restrictions".* Therefore, it would be valuable for future studies to investigate whether programs delivered by those without professional training or certifications in S&C influence aspects such as safety and the efficacy of S&C programs.

Judokas and S&C coaches across this study reported they predominantly source S&C information from viable sources such as S&C coaches and research articles, whereas approximately 1 in 5 uses social media. Similar findings were reported in grassroots soccer, where coaches principally used highly accessible sources such as social media, websites, and YouTube to inform their understanding and practice surrounding fundamental movement skills (15). Although the evidence base of such resources may be questioned (15), it is essential to acknowledge the need for highly accessible resources to improve the knowledge and practice surrounding S&C in judo. Furthermore, with literature indicating that athletes spend more time on mobile devices, this may be a more viable means of disseminating research-informed guidance in S&C (25). Therefore, greater attention may be placed on the implementation and effectiveness of social media as a tool for educating judokas and S&C coaches in judo.

Judokas and S&C coaches believed S&C was most important for improving *randori* performance, while S&C coaches equally thought it was important for judo-specific fitness (Figure 2). This acknowledges the vital contribution S&C plays in influencing certain aspects of judo performance (e.g., aerobic and anaerobic fitness, grip strength, and rate of force production). It has been reported that 70% of Olympic-standard judokas perform *randori* up to seven times per week, due to its relevance to the demands of competitive judo matches (23). The quantity, duration, and recovery periods used for *randori* can be manipulated to elicit different physical, physiological, and perceptual responses to training (9). Accordingly, using

S&C (general preparation) and *randori* (specific preparation), judo-specific fitness can be enhanced, which has been shown to underpin the execution of judo techniques and high-intensity grip disputes (33,36) and be a discriminating factor between competitive standards (e.g., national vs. regional) (20). For example, performance in neuromuscular tests (i.e., standing long jump, seated medicine ball throw, and handgrip strength) was moderately correlated with the Special Judo Fitness Test (SJFT) and Judogi Grip Strength Test (JGST) (42). Other research using the SJFT reported that judokas with superior performance were significantly correlated with higher anaerobic thresholds, lower blood lactate accumulation, and power production (14). Therefore, the perspectives of judokas and S&C coaches that S&C can support the development *randori* performance and judo-specific fitness are congruent with associated research.

The perception of judokas and S&C coaches indicated that S&C was important for strength, speed, power, injury reduction, and injury rehabilitation/return to play, but to less extent for improving flexibility (see Figure 3). The relationship between maximal force and rate of force production on judo performance has been widely investigated, providing evidence that the development of these physical attributes may transfer to judo-techniques (e.g., throwing: *harai-goshi* [hip], *sasae-tsurikomi-ashi* [foot], *morote-seoi-nage* [shoulder]. For example, research addressing the relationship between trunk muscle strength and judo-specific pulling performances in judokas using a specially designed system mimicking the judo technique *morote-seoi-nage* showed that the trunk flexors accounted for 69% of the mechanical work, therefore, advising judokas to develop trunk muscle strength to support dynamic pulling movements (29). Reducing the number and severity of injuries sustained by judoka and accelerating return to competition from injury is of interest given the high prevalence of injuries in judo, particularly in areas exposed to more significant stress and impacts during specific techniques and combat (4,34,55). Accordingly, injury prevention programs have been proposed that include judo-specific movements (e.g., leg techniques: *o-soto-gari or ouchi-gari*), strength, balance, and body awareness in vulnerable positions (24,46). When asked which S&C exercises are important for reducing judo-related injuries, judokas' most frequent responses fell under the miscellaneous category, whereas S&C coaches reported general strength. Given the broadness of these responses and the varied nature of injuries sustained in judo, it may infer that there is no common consensus on the most appropriate exercises to reduce injuries and that a more general or individualized approach to injury reduction may be

418 favored. Approximately two-thirds of participants in this study did not believe S&C was very
419 important for the development of flexibility, which is contrary to current research, which
420 suggests resistance exercises may improve flexibility and range of motion to similar effects as
421 static stretching (2,52). This may indicate that research on specific topics regarding the benefits
422 of S&C for physical performance in judoka could be more effectively educated and
423 disseminated.
424
425 Exercise preferences reported by participants were deadlift and variations for strength,
426 weightlifting and derivatives for speed and power, and judo-specific movements for agility and
427 judo-sepcific fitness (see Table 2). The deadlift being reported as the most important exercise
428 in judo is in contrast to S&C coaches in wrestling, who preferred the squat (30). However,
429 research suggests that both exercises can effectively improve lower body force production (54);
430 therefore, they are highly recommended as exercises in the S&C training programs of elite
431 judoka (26). Although there is limited evidence to suggest the direct benefits of weightlifting
432 on the performance of judoka, research on youth judoka and wrestling athletes demonstrated
433 that 12 weeks of weightlifting were >85% likely to improve (*moderate-large* effect size)
434 countermovement jump, horizontal jump, and sprinting (5m and 20m) performance (12).
435 Combining S&C with judo-specific training was common in the responses received throughout
436 this survey study. It has been suggested that judo-specific training should more prominently
437 occur during the specific preparation phase of an S&C training program, where the focus shifts
438 to judo-specific rate of force development and conditioning (26). For example, *nage-komi* can
439 improve aerobic and anaerobic fitness or *randori* to mimic the demands of judo matches (17).
440 Although highly judo-specific actions may appear beyond the scope of an S&C coach, given
441 the high prevalence of judo belts held by S&C coaches in this study, these exercises may be
442 effectively applied.
443
444 Judokas and S&C coaches reported that periodization was a significant issue and disadvantage
445 when implementing S&C and that this was an area for desired improvement. However, it is
446 uncertain from our findings whether this is associated with the ability of judokas and S&C
447 coaches to periodize S&C programs effectively or due to communication and logistical issues.
448 Desired improvements regarding periodization are logical given that research in judo has
449 demonstrated the efficacy of different periodization strategies during the annual training season
450 to improve physical performance (e.g., aerobic and anaerobic capacity, and number of throws

in a judo-specific test) (16,18,47). Research investigating the influence of different periodization strategies (i.e., traditional vs. daily undulating) in adolescent elite judoka found they were similar in developing one-repetition maximum strength from 5.5-13.5% in the squat, bench press, bench pull, and lat pull-down movement, respectively (61). To monitor training load, using ratings of perceived exertion (RPE) and session-RPE is effective across different ages, genders, and standards (1,8). For example, Bromley et al. (8) reported good correlations between session-RPE, lactate, and mental effort, with a single increase in reported RPE values resulting in a 2.1 unit increase in physical and 1.4 unit increase in mental effort. Therefore, using RPE may provide a simple and proactive approach to monitoring and adjusting training load in judo and warrants further investigation.

Finally, it was widely proposed by judokas and S&C coaches that more judo-specific equipment, movement, and training were needed. Prior research has shown that partner work provides limited resistance during specific judo techniques; therefore, using specialized equipment may enable more appropriate training methods. For example, Blais et al. (5) developed a judo-specific machine that mimics the *morote-seoi-nage* throwing technique and demonstrated that it can provide superior and progressive resistance compared to partner work. Other research demonstrated the validity and reliability of a judo-specific ergometer (JERGo system), which showed acceptable correlations (r = 0.41-0.88) for muscle activity during *kuzushi* compared to partner work (28). Although this specialized equipment provides promising results, the expense may limit their wider implementation. To measure the efficacy (i.e., improvements in speed, motion, or displacement) of judo-specific or alternative training methods, cost-effective equipment such as linear position transducers (51) or mobile applications adapted for judo movements may be considered.

The limitations of this study include (a) a standardized survey was adapted from prior research whereby the use of alternate methods (e.g., focus groups) may have provided participants the opportunity to answer questions in more depth; (b) the survey used was restricted in length which led to some questions providing somewhat superficial responses, however, follow up questions may have been beneficial; and (c) the majority of judokas and S&C coaches were predominantly from one geographical location (Brazil), making it challenging to undertake a deeper analysis across a wider demographic due to unbalanced samples. However, given that this is the first study of this topic area to be conducted in judo, a broad basis of information

must be initially provided for future research to investigate interesting and contemporary areas in more depth.

This study provides needed evidence on the contemporary S&C practices of judokas and S&C coaches. Exercises such as deadlifts (including variations) for strength, weightlifting (including derivatives) for speed and power, and judo-specific movements for agility and fitness were commonly prescribed. Judokas and S&C coaches reported S&C to be highly important for the physical preparation of judokas, reducing the occurrence of injuries, and optimizing performance in judo competitions. The most reported issues and improvements were related to periodization, such as balancing S&C around judo practice and competition schedules. Judokas and S&C coaches reported they would like to see a greater emphasis on judo-specific S&C in the future. These findings may support further research and the production of education and qualification resources concerning effective S&C practices in judo.

Practical Applications

The information included in this study is valuable for those pursuing or currently employing S&C practices in judo. Especially for judokas and S&C coaches to align and explain their practices with other experienced practitioners from different countries and standards. Furthermore, may benefit the wider support team (e.g., sports psychologists, sports therapists, physiotherapists) given the growing inter- and transdisciplinary nature of sports.

Judokas and S&C coaches should continue to seek S&C information from viable sources (e.g., S&C coaches, research articles) and undertake relevant education and qualifications which may enhance the effectiveness of S&C programs. This education should focus on key areas outlined in this study, such as the development of strength, speed, power, agility, injury reduction, and judo-specific fitness. Furthermore, with judo evolving from a physical preparation and technology integration standpoint, those delivering S&C should stay abreast of such developments, which may provide competitive advantages.

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Appendix

Judoka Survey

- Refers to questions with multiple-choice answers
- Refers to questions with single-choice answers

A) Informed Consent

- Agree
- Disagree

B) Background Information

Q1. Sex?

- Male
- Female
- Prefer not to say

Q2. Age? (must be over 18 years old)

Q3. Number of years' experience as a judoka?

Q4. What is the highest level of competition that you have competed in judo?

- International
- National
- Regional
- State
- Municipal
- Other

Q5. Which country are you currently based?

C) Education, Qualifications, and Prescription

Q6. What is your highest level of education?

- Secondary School
- Higher Diploma/Associate Degree
- Bachelor's Degree
- Master's degree
- Doctor of Philosophy (Ph.D.)
- Other

Q7. What was the subject area of your highest level of education?

Q8. Do you possess a strength and conditioning qualification with any of the below organizations or any other related fitness qualification?

- Australian Strength and Conditioning Association (ASCA)
- National Strength and Conditioning Association (NSCA)
- Collegiate Strength and Conditioning Coaches Association (CSCCa)
- United Kingdom Strength and Conditioning Association (UKSCA)
- None
- Other

Q9. What is your highest level of judo qualification?

- Black Belt 1st dan
- Black Belt 2nd dan
- Black Belt 3rd dan
- Black Belt 4th dan
- Black Belt 5th dan
- Coral Belt 6th dan
- Coral Belt 7th dan
- Coral Belt 8th dan
- None
- Other

Q10. How often do you obtain strength and conditioning information from the following sources?

	1 = Never	2 = Rarely	3 = Sometimes	4 = Commonly	5 = Always
Judo Coaches					
Judokas					
Strength and Conditioning Coaches					
Sports Therapists					
Physiotherapists					
Coaching Courses					
Research Articles					
Social Media					
Books and Magazines					
Other					

Q11. Who is mainly responsible for prescribing strength and conditioning exercises for you?

- Manager
- Head Coach
- Assistant Coach
- Independently (Yourself)
- Trainer
- Strength and Conditioning Coach
- Sports Therapist
- Physiotherapist
- Other: _____

<u>D) Views on Strength and Conditioning</u>

Q12. How important is strength and conditioning for the following components?

	1 = Not Important	2 = Slightly Important	3 = Moderately Important	4 = Important	5 = Very Important

Uchi-Komi (repetitive technical training)					
Nage-Komi (repetitive throwing training)					
Randori (combat or fight practice)					
Transition to groundwork					
Grip training					
Osae-Waza training (hold-down training)					
Judo-Specific Fitness					
Overall Judo Performance					

Q13. How important is strength and conditioning for the following components?

	1 = Not Important	2 = Slightly Important	3 = Moderately Important	4 = Important	5 = Very Important
Strength					
Speed and Power					
Injury Reduction					
Injury Rehabilitation/ Return to Competition					

Q14. How effective is your current strength and conditioning program for your judo performance?

- 1 = Not Effective
- 2 = Slightly Effective
- 3 = Moderately Effective
- 4 = Effective
- 5 = Very Effective

Q15. Please explain why?

Q16. Please share your personal views on strength and conditioning for judo?

E) Exercise Selection

Q17. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for **STRENGTH DEVELOPMENT**?

1.

2.

3.

Q17.1 Explain why you have listed the **'FIRST'** exercise most important?

Q18. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for **SPEED AND POWER DEVELOPMENT**?

1.

2.

3.

Q18.1 Explain why you have listed the **'FIRST'** exercise most important?

Q19. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for **AGILITY**?

1.

2.

3.

Q19.1 Explain why you have listed the **'FIRST'** exercise most important?

Q20. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for reducing **JUDO-RELATED INJURIES**?

1.

2.

3.

Q20.1 Explain why you have listed the **'FIRST'** exercise most important?

Q21. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for reducing **JUDO-SPECIFIC FITNESS**?

1.

2.

3.

Q21.1 Explain why you have listed the **'FIRST'** exercise most important?

F) Issues and Improvements

Q22. Explain the biggest issues you face when implementing strength and conditioning?

Q23. Explain any disadvantages associated with strength and conditioning?

Q24. Given unlimited time and resources, how would you change or improve your current strength and conditioning provisions?

Q25. What developments or advancements do you believe will be integrated into judo-specific strength and conditioning in the future?

Strength and Conditioning Coach Survey

- Refers to questions with multiple-choice answers
- Refers to questions with single-choice answers

A) Informed Consent

- Agree
- Disagree

B) Background Information

Q1. Sex?

- Male
- Female
- Prefer not to say

Q2. Age? (must be over 18 years old)

Q3. Number of years' experience as a judo strength and conditioning coach?

Q4. What is the highest level of athlete you have worked with in judo?

- International
- National
- Regional
- State
- Municipal
- Other

Q5. Which country are you currently based?

C) Education, Qualifications, and Prescription

Q6. What is your highest level of education?

- Secondary School
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Judokas					
Strength and Conditioning Coaches					
Sports Therapists					

Physiotherapists					
Coaching Courses					
Research Articles					
Social Media					
Books and Magazines					
Other					

Q11. Which other personnel besides strength and conditioning coaches do you see prescribing strength and conditioning exercises for judokas?

- Manager
- Head Coach
- Assistant Coach
- Independently (Yourself)
- Trainer
- Strength and Conditioning Coach
- Sports Therapist
- Physiotherapist
- Other: _____

<u>D) Views on Strength and Conditioning</u>

Q12. How important is strength and conditioning for the following components?

	1 = Not Important	2 = Slightly Important	3 = Moderately Important	4 = Important	5 = Very Important
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Judo-Specific Fitness					
Overall Judo Performance					

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<u>E) Exercise Selection</u>

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1.
2.
3.

Q17.1 Explain why you have listed the **'FIRST'** exercise most important?

Q18. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for **SPEED AND POWER DEVELOPMENT**?

1.
2.
3.

Q18.1 Explain why you have listed the **'FIRST'** exercise most important?

Q19. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for **AGILITY**?

1.
2.
3.

Q19.1 Explain why you have listed the **'FIRST'** exercise most important?

Q20. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for reducing **JUDO-RELATED INJURIES**?

1.
2.
3.

Q20.1 Explain why you have listed the **'FIRST'** exercise most important?

Q21. Name up to '**THREE'** strength and conditioning exercises **in order** of importance**,** you consider most important for reducing **JUDO-SPECIFIC FITNESS**?

1.

2.

3.

Q21.1 Explain why you have listed the **'FIRST'** exercise most important?

F) Issues and Improvements

Q22. Explain the biggest issues you face when implementing strength and conditioning?

Q23. Explain any disadvantages associated with strength and conditioning?

Q24. Given unlimited time and resources, how would you change or improve your current strength and conditioning provisions?

Q25. What developments or advancements do you believe will be integrated into judo-specific strength and conditioning in the future?