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Modeling of grasps in judo competition contests

Michel Calmet^{1,2}, Bianca Miarka², Emerson Franchini²

1 – Montpellier University, France;

2 – Martial Arts and Combat Sports Research Group, School of Physical Education and Sport, University of São Paulo, Brazil

Abstract

In judo, the two contestants get close to each other, perform their grasps, move on the mat and attack. The approaches and kumi-kata (grip technique) give way to specific behaviors between the two contestants. The briefness and the capacity of simultaneous actions, the multiple interactions and the result at stake result in a complex system that is most of the time clarified by the coach to the contestant. A computerized observation may help to highlight some actions associated to success from that complex system. The winners of 35 contests were analyzed (9 beginners, 16 intermediate levels, and 10 experts) through their behaviors (approaches and kumi-kata) and positions. The results enable experts to assume lengths (15.8 ± 9.5 s) and amount (9 ± 6) of the combat phases (lapse of time between beginning and stop, announced by the referee). Beginners approach each other with much care and precision, mainly holding their opponents with both hands for the projection. The percentage of total time spent by beginners and experts grabbing the opponent's judogi with both hands, attack and throw was 86% and 24%, respectively, indicating a much lower time spent between grip contact and technique application in experts compared to beginners.

Keywords: judo, grip, competition, technique, tactics

Introduction

During a judo combat, athletes aim to project their opponent to the ground or to obtain control during groundwork. For instance, technical and tactical behaviors are substantial for attacks with combinations of tasks in different situations, something which is necessary for an effective application of techniques (Franchini *et al.*, 2008). In this way, we may regard competition in combat sports as a set of action sequences between competitors. These combats represent "complex systems with very different forms but that may be studied with similar methods" (Zwirn, 2003; p.28). During competition combats, the shortness of actions, the possibility of simultaneous actions and multiple interactions lead to a long, difficult and close analysis. Yet, most of the time, the coach guides the contestant through various parts of that complexity, although computerized observation is better suited to highlight those "rationality islands" (Fourez, 1997) due to its precision. Competition brings forward the technical-tactical uncertainty of the opponent's behavior. The result at stake requires skills that coaches and competitors must acquire - in other words, "handling the situations as a whole during the activity" (Delignières, 2009). This last research is based on the "Top Down" technique (Boulanger, 2005), aiming to clarify that complexity within combat sport activities in general, with judo contests in particular.

This complex system, which is stated in the form of feedback loops, changes over time in a way that depends on the way it shows us different tasks and a constant intermittence that can be described with different phases. The first phase starts at the referee's signal (*hajime*), and ends when the referee stops the contest (*matte*), momentarily or permanently (*soremade*). In the first case, this means when the judokas step out of the fighting area, or when one or both of them practice ground combat (*ne-waza*), but not in an effective way. On the other hand, a permanent halt means that the fighting time is over or when a decisive point (*ippon*) is scored. In the first case, each phase begins with a standing up position (*tachi-waza*), apart from rare short pauses induced by specific rules and situations called *sono-mama*, and may go on with ground (*ne-waza*) activity (Castarlenas and Planas, 1997). The phase begins with the referee's signal and is followed by an attempt of grappling the opponent's *judogi* (judo uniform). This is an important period of time that brings information for action (attack/defense, for instance), as the type of grip limits the attacks and defenses that are possible to perform. Also, different types of grasps and attacks can occur in a single phase. For achieving that, both judokas move on the mat so as to prompt attacking opportunities. Therefore, the attacker grasps the opponent's *judogi* and the grasp may be done either with one or two hands. The *kumi-kata* integrates the approach and 'grappling' phases, and naturally the hands' positioning, the stature (orientation arms/body/feet) and the use of all these notions into actions (destabilization, displacements, attacks) (Giuseppi, 1997). In other words, the attacker who initiates a phase is closer for the attacks, and remains in contact during the projections.

The attacker's uncertainty into advancing comes from that grappling that allows him/her to defend and attack in many positions. The classical observation analysis (based on the attack and grappling directions) underlines the fact that judokas attack in a span of four or six different directions with a single grasp; that very grasp, the displacements and the attacks in various complementary directions represent the judoka's attacking system (Calmet *et al.*, 2006; Franchini *et al.*, 2008). Grapping before the other judoka means advancing first, which means that the opponent gives opposition to that action. In order to project an opponent, a judoka must grasp and get close to him/her. Therefore, the attacker adopts various and interactive behaviors adapted to their opponent. Studies have been carried out about these fighting phases (Castarlenas and Planas, 1997) without leading to conclusions on these behaviors. Thus, the aim of the current work is to improve the identification of the approach and grappling phases, together with their evolutions according to the practice levels, based on global and complex analyses of the judo combats.

2. Methods

2.1. General approach

The procedures included performance indicators consisting of eight different behaviors (cf. Figure 1), their positions (taking into account eight angular sectors) and their corresponding times. The opponent was considered as a fixed virtual center point and the attacker as an object getting closer or farther around that virtual center point (cf. Figure 1). The noted change is based on a sector position changing or a behavior changing.

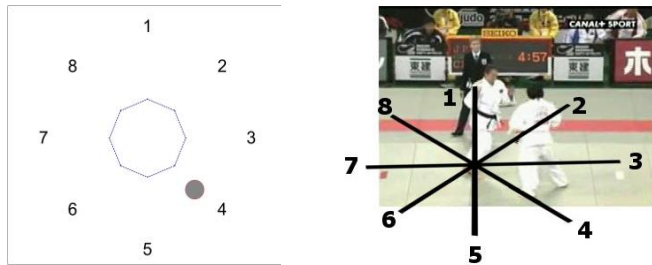
8 behaviors of the attacker opposed to the opponent	The attacker's position (gray dot n°4) on the mat with the 8 sectors.	
Stand by X		
Tries to grasp without contact		
Tries to grasp with contact		
1 hand grasping		
1 hand grasping, the other in contact		
Both hands grasping		
Attack		
Throw down		
Attacker's behavior = Stand by (X); Attacker's position = 4		

Figure 1: Explanations of the behaviors and rotations noted during a combat.

The phases were announced by the referee, taking into account only the *tachi-waza* actions.

2.2. Accuracy and objectivity

To obtain more accuracy in the information about the combat structure and to describe the behavior of judokas, we use computers tools to develop the modeling of grasps and attacks. Several computer programs can analyze recording sequences and read data. In this line, spreadsheets can bring more flexible solutions, since they are graphic softwares/calculators; they also have data units (the latest versions possess more than 16000 columns and 1.000.000 lines) and a programming language. Afterwards, we developed our own tools on a spreadsheet with a Visual Basic application in order to note down the collected data, and to model them. These tools, associated with the analysis of the video sequence, helped us to identify the positions and angles of the judokas on the mat. Figure 2 is an example of an analysis for changing the positions and behaviors of the judokas (we may set the values with the arrows), where the video was not displayed on the working screen.

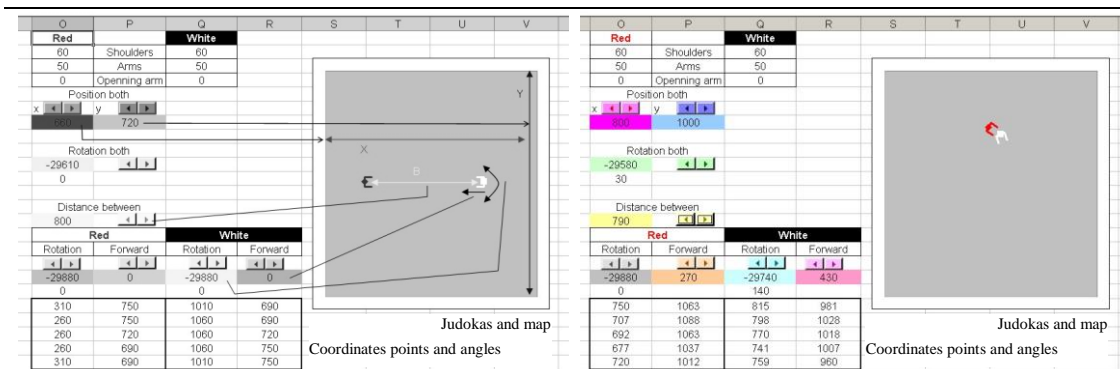


Figure 2: Example of this VBA tool used to identify the judoka's positions and behaviors on the mat (grey area); here, the image of the video sequence is not displayed.

The objectivity of actions during judo matches were examined previously by our group (Miarka *et al.*, 2009) using the sample concordance and correlation coefficient (CCC) (Barnhart *et al.*, 2010). In that study, 20 matches were analyzed twice by one evaluator and once by three evaluators to check intra and inter-evaluator objectivity, respectively. In those matches some grip positions did not occur (right collar and left collar; right collar and right sleeve; left collar and left sleeve) as these positions are not commonly used in judo, especially for the positions with both grips on the same side, because this action can result in penalization. For one position (right back and left sleeve) the video was not clear enough to a good analysis. Briefly, we found strong CCC for gripping time (0.84 and 0.99 for inter and intra-evaluator, respectively), moderate (0.63) inter-evaluator CCC for right sleeve grip, and strong CCC for seven other grip combinations (varying from 0.87 to 0.99 for both inter and intra-evaluator CCC). However, it is important to note that for the present study the focus of analysis was not directed to specific positions, which indicate that the

concordance would be in the upper limit of this range. Similar behaviors were also analyzed in other study (Salvador *et al.*, 1999) and the objectivity, assessed through the intraclass correlation coefficient, was higher than 0.93.

2.3. Modeling

The model obtained, with tool presented in Figure 2, is as complex as in true situations (Delahaye, 2006), so we have improved the application and chosen the tool presented on Figure 3. The Video Sequence is integrated within the spreadsheet; the image by image positioning is loaded, after which the user records the data on the line corresponding to the number matching the image, in the column corresponding to the observed behavior.

secondes	Orientation	Stand by	Tries to grasp without contact	Tries to grasp with contact	1 grasped hand	1 grasped hand, the other in contact	2 grasped hand	attack	Throw
101	3,080								
102	3,120								
103	3,160								
104	3,200								
105	3,240	7	1						
106	3,280								
107	3,320								
108	3,360								

Figure 3: Tool used to identify the data (angles and behaviors on the mat).

The user may display the video sequence at normal speed or image by image. The precision varies from 0.033s up to 0.040s for the videos recorded, at an amount of 30 or 25 images per second. The user records the orientation and behavior of the contestant on a line matching the number of the image. After several tests with various video sequences, that tool proved to be efficient enough to accept variations by one or two images for a given behavior; the obtained results do not show these variations. Indeed, a variation of 0.033 or 0.066s is not significant for a few seconds' description and interpretation, since data mostly possessed many thousands of lines (1 second represents 30 images, therefore 30 lines; 1 minute represents 1800 lines). All data were collected by the same user (5th Dan in judo, national competitor, with experience in technical and tactical analysis of judo matches).

2.4. Sample characteristics and judo matches analyzed

The sample was composed by winners of three different groups: (1) nine students in sports, combat sports beginners (four females / five males) of the same university level and who had attended judo classes for at least 20 hours with the same teacher. No organization by weight categories was set, but there was no heavy-weight among these nine judokas. The duration of a combat was 1min and was stopped when one judoka got two advantages. There was no *ne-waza* (ground combat) practice. The phase of data recording started at the referee's signal (*hajime*) and was stopped when an advantage was scored or when the referee announced *matte* (stop), or when a judoka stepped out of the combat area; (2) Sixteen intermediate judokas (nine females, seven males) who had taken their official Dan (black belt grade) examinations. The judokas were selected in similar weight groups, but not in real categories as in official competitions. The 16 contestants varied from "light" to "heavy" weight categories. These official Dan examination regulations brought the contestants all to the same level. The duration of a combat was 3min; and it was either stopped by the scoring of a winning point, by the time limit or by the giving up of one of the contestants. The phase of data recording started at the referee's signal and stopped when the referee announced *matte* (stop) or when the judokas proceeded to *ne-waza* (ground combat); (3) Ten international expert level judokas (five females [+78 kg, -78 kg (2), -70 kg, -63 kg] and five males [-60 kg (2), -66 kg (2), -90 kg] were also analyzed. The required standard for analysis was based on their participation into international competitions. The duration of a combat was 5min; it was either stopped by the scoring of a winning point, or by the time limit or by the giving up of one of the contestants. The phase of data recording started at the referee's signal and stopped when the referee announced *matte* (stop) or when the judokas proceeded to *ne-waza* (ground combat).

Since the duration of the combat was different from one another, the analysis was focused on the combat phases (i.e., the time between *hajime* and *matte*).

2.5. Statistical Analysis

Measures of centrality and dispersion are shown as mean \pm *SD*. The ANOVA one-way was conducted in order to compare modes of applications and the Bonferroni test was used as a *post hoc* to identify specific differences between combat phases (with a margin of 5%).

3. Results

The results cover 169 combat phases and their global directions, as well as the ones spent for each behavior, and the frequency of the attacks (Table 1).

Table 1: Number of phases and durations of phases.

Levels	Theoretical duration of the combat	Phases		
		Total by level	Average by combat	Average duration (s)
Beginner	1 min	20	2 ± 1	16.3± 9.9
Intermediate	3 min	60	4 ± 3	13.0± 5.6
Expert	5 min	89	9 ± 6	15.8± 9.5

There was no significant difference between the combat phase for the three groups ($F_{2,166}=2.4$; $p=0.094$).

Thus, it was possible to compare (cf. Figure 4) the behaviors during the approach and grapping of the judokas during these combat phases.

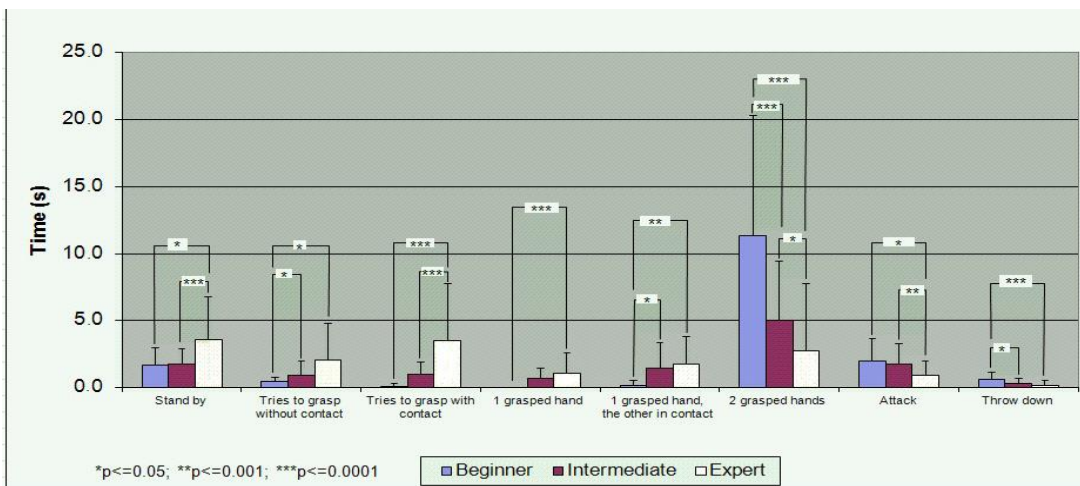


Figure 4: Time (s) spent at different behaviors during a judo match.

Figure 4 shows significant differences in all behaviors from beginners up to experts. The combat time with a two-hand grip is different at all levels (see Figure 6 for precise values).

The three groups are different especially concerning the time spent with two grasped hands.

Expert spent more time than the other two groups in standby and time to grasp with contact, and they realized less attacks.

Beginner grasped directly the opponent (the items "Tries to grasp without contact" and "One grasped hand, the other in contact" are significant different with the two other groups) and the time to throw the opponent is longer.

Frequency of the attacks:

Experts attack less than the intermediate or beginner judokas, but in two thirds of the phases there occurs an attack (cf. Table 2).

Table 2: Frequency of the attacks during the phases.

Judokas	Frequency phases with attacks
9 beginner	80.0%
16 intermediate	86.7%
10 expert	67.4%

To explicit Figure 4, we calculated the average activity inherent to each category (cf. Figure 5), and present one phase for each level (Table 3 with Panel A, B, and C).

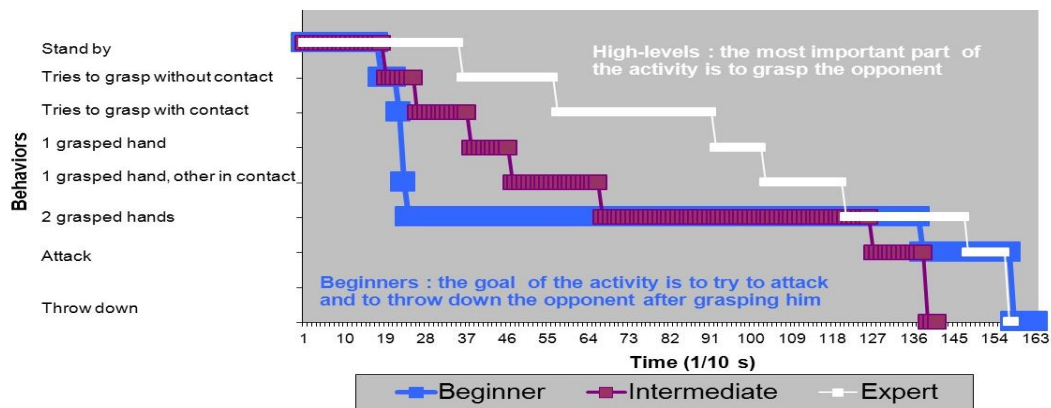


Figure 5: Model of the profiles obtained during a combat phase.

Table 3: Three phases of combats with a throw.

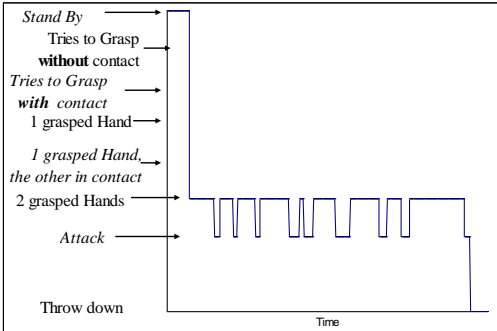
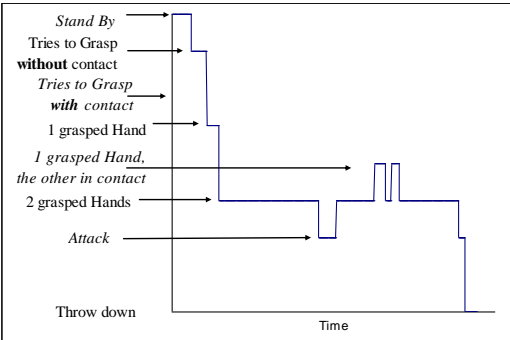
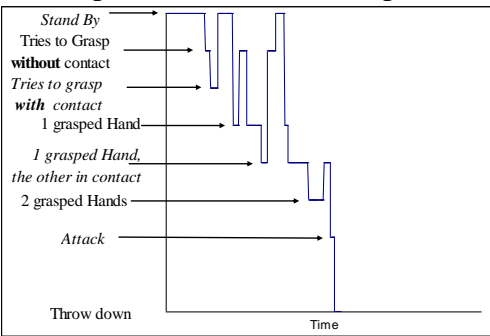
Level and behavior during one phase	Characteristics
<p>Panel A: Beginners, students in evaluation contests</p> 	<p>Straight from reverence to both hands gripping without release. Most of the combat is done in close combat.</p> <p>duration 19.2s; 9 attacks; 1 throw down</p>
<p>Panel B: Intermediate 2° Dan test</p> 	<p>"Cautious" movement from reverence to 2-hand gripping. Many steps before an attack. Then, contact is done and no break-up. Then, contact is done and no break-up.</p> <p>duration 18.1s; 2 attacks; 1 throw down</p>
<p>Panel C: Expert, international competition 2007</p> 	<p>"Very cautious" movement from reverence to gripping (one or two hands), working time with two hands gripped being very short, there are some break-ups. Most of the combat is done at a distance to insure the gripping.</p> <p>duration 10.6s; 1 attack; 1 throw down</p>

Figure 6

Behaviors	Stand by			TGWoC			TGWiC			1GH			1GH-OC			2GH			Attack			Throw down		
	B	P	E	B	P	E	B	P	E	B	P	E	B	P	E	B	P	E	B	P	E	B	P	E
Level																								
Time	1.7	1.8	3.5	0.4	0.9	2.1	0.1	1.0	3.5	0.0	0.7	1.1	0.1	1.5	1.7	11.4	5.1	2.7	2.0	1.7	0.9	0.6	0.3	0.2
±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
SD	1.3	1.1	3.2	0.3	1.1	2.8	0.3	0.9	4.2	0.0	0.7	1.5	0.4	1.9	2.1	8.9	4.4	5.0	1.7	1.6	1.0	0.6	0.4	0.4
(s)																								
Anova	F2;166=11; p<0.0001			F2;166=7.6; p=0.001			F2;166=17.5; p<0.0001			F2;166=7.7; p=0.001			F2;166=5.8; p=0.004			F2;166=21.3; p<0.0001			F2;166=9.4; p=0.000			F2;166=8.9; p=0.000		
Bonfer-roni's	0.887 (N)			0.352 (N)			0.258 (N)			0.022 (N)			0.008 (Y)			<0.0001 (Y)			0.440 (N)			0.006 (Y)		
Tests	<0.0001 (Y)			0.002 (Y)			<0.0001 (Y)			0.044 (N)			0.371 (N)			0.010 (Y)			0.000 (Y)			0.067 (N)		
	0.003 (Y)			0.002 (Y)			<0.0001 (Y)			0.000 (Y)			0.001 (Y)			<0.0001 (Y)			0.001 (Y)			<0.0001 (Y)		

Figure 6: Comparisons of the durations spent for each behavior.

TGWoC = Tries to grasp Without Contact; TGWiC = Tries to grasp With Contact; 1GH = 1 Graped Hand

1GH-OC = 1 Graped Hand the Other in Contact; 2GH = 2 Graped Hands

B = Beginner; P = Proficient; E = Expert

(Y) Bonferroni test is significant; (N) Bonferroni test is not significant

4. Discussion

The main finding of the present study was that beginners get close to each other and take their gripping at once (Calmet, 1991), and spend most of their combat time in figuring how to organize their attack and to throw down (Table 3, Panel A). The intermediate judokas (Dan Exam) presented a transitional behavior. They move "cautiously" towards each other to finalize their action. There is only one process, from reaching from afar to close-up contact (Table 3, Panel B). A double way of proceeding (moving onward/backward) is often adopted by the expert level judokas. For them, most of the combat is spent in gripping the opponent without being gripped (Table 3, Panel C).

The time spent in both hand-gripping to attack and throw spans from 86% to 53% down to 24% for beginner, intermediate and expert judokas, respectively.

In table 1, the values for experts correspond to those noted in the corresponding literature (11 to 15 *tachi-waza* combat sequences of around 15 seconds each).

Figure 5 illustrates in a linear way the average behaviors and differentiates the behaviors between the categories, from stand-by to a gripping *kumi-kata*. The factual reality reminds us that for all athletes the phases do not always end up into a projection, an attack is not always successful, and after an aborted attack judokas adopt a gripping attitude again. Thus, there are several series of behaviors. It's why, in order to illustrate the reality and the process of a phase, we present three phases, one per level (Table 3).

We must extend the analysis to confirm whether there are no differences according to weight

categories, and whether the durations of the combat phases are identical regardless of the judokas' level.

Further objectives would still be dedicated to analysis and description. Prediction, in its genuine sense of predicting the evolution of a flux or a "traffic" (Lebacque, 2006), is not really relevant in this case, since our research domain is more oriented to description and explanation in a teaching scope. The models obtained can be considered "rationality islands", because they highlight behaviors and we can expect an increase in training for judo. This will help in preparing solutions for improvements and neutralization of various behaviors during competitions.

Being aware of these results within our Training Centers could bring answers to questions, such as:

- How to train the beginners, pedagogically speaking?
- When is the transition from an "academic/studying" gripping to a "fighting" gripping?
- Whether it is necessary to set a regulation for the experts?

That debate is complex, and only one solution is not enough to find the right balance, therefore a global approach with local specific applications or a systemic approach is necessary.

5. Conclusions

The grip approach differed considerably among beginners, intermediate and expert level's judokas. The grip time is longer for beginners, who spend most of the time with grip contact and trying to apply a technique. Intermediate level judokas perform only one process, from reaching from afar to close-up contact, while expert level expert judokas spend more time in grip contest (trying to grip the opponent without being gripped) and less time with both contact grips. Additionally, the expert group spends less time between the grip and the technique execution. These results can be used to direct the technical and tactical training in order to improve grip contest.

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