ORIGINAL ARTICLE

Time-motion analysis during elite judo combats (defragmenting the gripping time)

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A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: Time-motion analysis of judo combats allows both coaches and athletes to optimise the training and competition processes. One of the most important actions in achieving winning or losing is the moment of the gripping. The aim of this study is knowledge about the temporal structure of elite judo combat by the sex and weight category of combatants, decomposing the gripping time into "trying gripping time" and "accomplished gripping time".

Material and Methods: The observational design was punctual, nomothetic, and multidimensional. A total of 181 judokas were analysed in 150 matches at high international level in three female weight categories (−48, 48-63, and +78 kg) and three male weight categories (−60, 60-81, and +100 kg). An observation tool was performed to analyse the main time-motion indicators in judo combat. In addition to the categorisation of variables commonly used by the previous by literature, the total gripping time (*kumi kata*) was divided into "trying" and "accomplished" gripping time. The validity and reliability of the data were checked to ensure the scientific rigour of the observational research.

Results: There are temporal differences between some weight categories – both within and between the sexes, particularly in the variables related to *kumi kata* (gripping). Indeed, 59.3% of effort sequences comprised either "trying gripping time" or "accomplished gripping time".

Conclusions: This suggests the importance of adapting technical-tactical and conditioning training associated with *kumi kata* to the records obtained for these two elements of the total gripping time, which will help optimise elite judo training by sex and weight category.

Keywords: accomplished gripping time • kumi kata • observational methodology • trying gripping time • validity

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Tutorial Video: https://www.youtube.com/watch?v=iFMIOjTfvtU

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Observational methodology – a scientific approach that is capable of gathering data directly from participants in different contexts without eliciting a response from them. This is achieved through the direct capture of perceivable information, mainly visual.

Lince® – multiplatform sport analysis software specifically designed to analyse observational information and to control the quality of the data.

Technical and tactical skills – the actions and decisions of athletes to gain an advantage in any opposition situation.

Effort sequence –a temporary sequence consisting of a set of technical and tactical skills from a starting point to another endpoint.

Time-motion analysis – direct and continuous observation of a task or set of these using a timekeeping device to record the time taken from start to finish.

Ippon – one point. Achieved through the execution of a valid technique on the opponent [41].

Training session – ***noun*** a period of time during which an athlete trains, either alone, with a trainer or with their team [42].

Technique– ***noun*** a way of performing an action [42].

Tactics – ***plural noun*** the art of finding and implementing means to achieve immediate or short-term aims [42].

INTRODUCTION

An understanding of the temporal structure of a given sport is essential in order to bring training methods into line with competitive objectives [1]. Optimal training strategies are best determined by analysing the effort made in that sport, and should not only be sport-specific but should also be adapted to sex and competitive level [2, 3]. In recent decades, observational analysis has been shown to be important in combat sports. In judo, it can identify specific aspects or factors that coaches and athletes could improve in order to maximise performance [4-6].

The temporal structure of judo combat is intermittent with a combination of sequences of high-intensity effort and short pauses [6, 7-10]. According to the International Judo Federation (IJF), the real combat time is 5 minutes for men and 4 minutes for women [11], but these figures may vary. For example, it may be reduced in the case of an *ippon*, disqualification (*hansoku make*), or injury, but it may be longer if the pause between when a referee stops (*matte*) and restarts (*hajime*) combat is included. Also, both the real and total time may increase if there is a tie at the end of the match. In which case the "golden score" rule applies (i.e. the first judoka to score wins) [11]. Most authors have recorded total combat times of around 7 minutes [2, 12-16].

Castarlenas and Planas [14] report that judo matches are divided into 11 sequences of effort (8 standing and 3 on the ground), each of 15-30 s in duration with a further 7 pause or rest sequences of around 10 s duration each. Similar characteristics have been observed in subsequent studies, reinforcing this as an established temporal structure of judo combat, regardless of updated or new technical rules [12, 17-21]. However some recent studies have found significant differences in the temporal structure of judo combat according to the age [6, 22], the skill level [10, 18, 23, 24] and the sex [17-19, 25] of participants. Indeed total combat times differ for men and women with greater importance on groundwork (*ne waza*) for women.

Despite this research, few studies to date have analysed the temporal structure of judo combat among elite judo athletes [6]. Some authors have analysed temporal patterns among judokas [8, 26] but to our knowledge, none have examined the differences in temporal structure between sexes and weight categories among international judokas. Indeed, no studies have broken down the tactical time of gripping (*kumi kata*) into the two primary stages within the sequences of effort, even though both coaches and judokas recognise and develop these stages during training and competition. These stages are: 1) the time in which the judokas try to grip their opponent and 2) the time during which the grip is established. The first is a tactical period that involves contact, is mainly dynamic, and is required to analyse the opponent and take, in real time, the most appropriate decision or set of decisions to anticipate the opponent's moves and achieve a favourable outcome. The second period, which is more commonly analysed and comes before throws or groundwork, begins with mainly static, established gripping.

The aim of this study is knowledge about the temporal structure of elite judo combat by the sex and weight category of combatants, decomposing the gripping time into "trying gripping time" and "accomplished gripping time".

MATERIAL AND METHODS

Design

We used a punctual (records of different competitions. but assessed as one unit), nomothetic (different weight categories and sexes) and multidimensional (several criteria per record) observational design [27].

Match sample

In total, 150 elite judo matches of IJF tournaments (European Championships, World Cup, Grand Prix, Masters and World Championship) were analysed in the year 2010. We ensured that the sample included an equal proportion of men to women per weight category. Therefore, we analyzed 75 men's matches and 75 women's matches, distributed into three female weight categories: −48 kg (n = 25); 48-63 kg (n = 25); +78 kg (n = 25) and three male weight categories: −60 kg (n = 25); 60-81 kg (n = 25); +100 kg (n = 25), corresponding to lightweight, middleweight, and heavyweight, respectively. The sample was taken from a total of 181 judokas (88 men, 93 women) from 50 countries and no matches involving the same two fighters were observed in the same tournament. The competitive level of the athletes was heterogeneous: 53 of them were ranked in the top 10 of the IJF ranking, 65 between the ranking number 11 and 30 and 63 between the number 31 and 180. The studied matches were selected at random, but images had to be of good quality and without interruptions to be considered for inclusion (between the first order of the referee to start the match and the order to finish it, all the movements of the judokas could be completely and clearly observed). The records were obtained from different web portals (www.judovision.org, www.arajudo.com, www.judo.tv, www.JudoInside.com).

Measures: identification of judo performance through time-motion indicators

An observation tool was designed with a structure that combined a category system with a field format [27] to analyse the main time-motion indicators in judo combat. In this study, two new variables were added related to the gripping time (*kumi kata*) and were not included in previous studies. All the indicators are described below:

• total combat time (TCT): this was the total official time measured by the referees. It was defined as the period between the first order of the referee to start the match (*hajime*) and the order to finish the match (*soremade*), based on the protocol used to analyse the combat time frame described by Gorostiaga [2].

• total real-time (TRT): this was the total official time measured by the referees, plus the total pause time. The variable was obtained by adding the TCT to the total pause time in each match [14].

• sequences of effort (SE): these were each of the phases between when the referee gave an order to start *(hajime* or *yoshi)* or stop or indicate that time was up *(matte* or *soremade).* SE was considered to occur when the judokas began the match, each time they stopped to return to their initial positions to restart, or when the match was over. We quantified this indicator as the number of times SE occurred in each match [14].

• Displacement without contact (DWC): this was defined as the time between the referee's signal to start the match (*hajime*) and the first contact made to execute a grip (*kumi kata*). In this period athletes did not have any physical contact with each other, and it was defined according to the protocol used by Calmet in the analysis of combat time [28].

• Total gripping time (TOGT): this was defined as the total time spent gripping an opponent during a match, and was the time from the first contact between judokas until either contact with the opponent was broken or until a throw, based on the protocols used in the analysis of the combat time frame by Calmet et al. [18] and Miarka et al. [6]. In our study, we further divided this variable into the trying gripping time (TRGT) and the accomplished gripping time (ACGT), with the following definitions:

• TRGT: this was the time in which the judokas met each other and actively, dynamically tried to execute unsuccessfully a grip with two hands (*kumi kata*). The TRGT concludes when one of the two judokas is gripping his/her opponent with two hands or when the judoka attacks directly from this situation.

• ACGT (*kumi kata*): this was the time in which at least one of the two judokas was deemed to be gripping his/her opponent with two hands (*kumi kata*) and either remained static (i.e. isometric this way) or tried to dominate the opponent with their grip. To validate this variable, a session was held with experts, who agreed (100%) that the variable was valid. Most of the time, this *kumi kata* is with a sleeve and jacket lapel grip.

• Throwing time (*nage waza*) (TT): this was the standing fighting time in which one of the fighters tried, or managed, to throw the other. It was characterised by the intention to carry out throwing techniques (*nage waza*), in accordance with IJF rules, as defined by Gorostiaga [2].

• Groundwork combat time (*ne waza*) (GCT): this was the sum of the time during which the judokas fought on the floor, as described in the study by Castarlenas and Planas [14].

• Pause Time (PT): the recovery time was defined as the period between the signal for combat interruption (*matte*) and the signal to restart combat (*hajime*). *Sono mama* and *yoshi* commands (stopping and restarting the match) were not observed in this study [2].

• Sequence time effort (STE): this was the time that each one of the SEs lasts.

Procedures

The observation process included a training period carried out by the main observer, together with two other observers of time-motion indicators [28]. All the researchers were judo experts, had over ten years' experience in the sport and were physical education graduates. They analysed the various matches until they reached full agreement [29]. Following the data recording protocols for the observational method [30]. LINCE v. 1.1 software was used as a recording instrument [31].

Validity and reliability

The validity and reliability of the data were checked [32] to ensure the scientific rigour of the observational research. Validity was determined by assessing the consistency and robustness of concepts drawn from the theoretical framework and from the process used by the experts to design the observational instrument. A set of variables from the literature was used as the basis for the instrument [2, 6, 14, 17-19, 25, 33-35], and the specific time-motion indicators that comprise our study were added. Once designed, the observational instrument was reviewed and approved by a panel of ten judo experts, who replied to a questionnaire, showing 100% agreement on all indicators. This provided conceptual consistency, robustness and construct validity. We requested that experts should pay special attention to TRGT and ACGT, as new indicators and the original contribution of this study.

The intra-observer reliability of the principal investigator was determined by a systematic analysis of 12 matches, one per male and female weight category, analysed twice [28. 36]. An acceptable degree of agreement was found, with values between 0.998 and 1.000 for the intra-class correlation coefficient. Inter-observer reliability was determined by comparing two external evaluators' systematic analyses of the same 12 matches and comparing them with those of the principal observer, using Krippendorff's alpha coefficient (Ka). The resulting Ka values were between 0.998 and 1.000 for the different criteria, where a value above 0.8 is acceptable [37].

Table 1. Time-motion variables in judo combat.

Variable (indicators)	Combats						t-value	p-value
	all (n = 150)		male (n = 75)		female (n = 75)			
TRT (s)	278.3	±133.2	282.2	±130.7	274.3	±136.4	0.365	0.715
TCT(s)	200.2	±88.9	202.8	±86.2	197.5	±92.0	0.365	0.716
PT (s)	7.9	±3.2	8.2	±3.3	7.6	±3.1	1.114	0.267
GCT (s)	3.9	±2.6	3.2	±2.0	4.6	±2.7	–1.898	0.060
SE (n)	9.7	±4.9	9.6	±4.8	9.9	±5.1	–0.347	0.729
STE (s)	22.4	±7.1	23.0	±6.8	21.8	±7.3	1.048	0.296
DWC (s)	3.9	±2.3	3.9	±2.3	4.0	±2.4	–0.293	0.770
TOGT (s)	13.3	±5.6	14.5	±5.3	12.0	**±5.6***	2.826	0.005
TRGT (s)	6.6	±3.2	8.4	±3.1	4.7	**±2.0***	8.728	0.001
ACGT (s)	6.7	±3.8	6.1	±3.5	7.3	**±4.0***	–1.946	0.045
TT (s)	1.3	±0.5	1.3	±0.5	1.3	±0.5	0.376	0.707

Statistical analysis

The normality of the data was assessed with the Shapiro–Wilk and Kolmogorov–Smirnov tests. Descriptive statistics were calculated as the mean and the standard deviation for all variables under study. To evaluate any differences between each of the three weight categories by sex, we used one-way analysis of variance (ANOVA) and the student's t-test for differences between pairs, and the Sidak correction for multiple comparisons. To compare the sexes for the lightweight categories (−60 kg men and −48 kg women), the middleweight categories (−81 kg men and −63 kg women), and the heavyweight categories (+100 kg men and +78 kg women), we used the Student's t-test for two independent samples. Statistical significance was set at 5% ($p \leq 0.05$), and we used PASW Statistics for Windows (v.18. SPSS Inc. Chicago USA) for all statistical analyses.

RESULTS

The men took longer to execute a grip (TOGT and TRGT) than women (14.5 ±5.3 s vs. 12 ±5.6 s, and 8.4 ±3.1 s vs. 4.7 ±2.0 s respectively, $p<0.001$), but that women spent longer with a real grip on their opponents (ACGT) than men (7.3 ±4.0 s vs 6.1 ±3.5 s, $p<0.05$) (Table 1).

The weight of men affected the way matches developed, with significant differences in the TOGT and accomplished *kumi kata* time (ACGT). The heavyweight judokas had a longer TOGT (17.1 ±6.5 s) than the lightweight (12.9 ±3.6 s) and middleweight fighters (13.7 ±4.6 s). These differences were mainly in the ACGT, which was 9.5 ±3.7 s for the >100 kg group, 4.6 ±1.7 for the lightweight group, and 4.3 ±1.9 for the middleweight group. However, the heavyweight judokas spent significantly less time on groundwork (1.8 ±1.2 s) than either the lightweight or middleweight judokas (3.7 ±3.2 and 4.2 ±3.5 s respectively) ($p<0.05$) (Table 2).

The differences observed in the gripping indicators among men were also present among women. As in the men's matches, women in the heavyweight category had longer TOGT than either the lightweight (15.7 ±6.6 s vs. 9.5 ±3.4 s) or middleweight (10.9 ±4.4 s) categories ($p<0.05$); heavyweight women also had longer TRGTs than either the lightweight or middleweight categories (5.7 ±2.2 s vs 4.0 ±1.7 s and 4.5 ±1.8, respectively; $p<0.001$). Also, the heavyweight judokas had longer ACGTs compared with the lightweight and middleweight categories (10.1 ±5.0 s vs 5.5 ±2.1 s and 6.4 ±2.9, respectively; $p<0.001$). However, lightweight competitors had longer DWC times than either the middleweight or heavyweight judokas (5.1 ±2.5 s vs 3.2 ±2.1 s and 3.5 ±2.1, respectively; $p<0.05$). (Table 3).

In the heavyweight category, significant differences were only found in the TRGT, which was

Table 2. Comparison of time-motion variables in judo combats by male weight competition categories.

Variable (indicator)	<60 kg (n = 25)		<81 kg (n = 25)		>100 kg (n = 25)			F-value	p-value
TRT (s)	236.1	±132.8	321.2	±115.6	289.4	±133.5		2.844	0.065
CTT (s)	173.8	±91.1	233.3	**±78.2***	201.5	±81.3		3.162	0.048
PT (s)	7.6	±3.3	8.0	±2.8	8.9	±3.6		1.037	0.360
GCT (s)	3.7	±3.2	4.2	±3.5	1.8	±1.2	† ‡	4.638	0.020
SE (n)	8.4	±4.9	10.9	±4.5	9.4	±5.0		1.695	0.191
STE (s)	21.8	±6.1	22.8	±6.1	24.4	±8.1		0.900	0.411
DWC (s)	3.9	±2.4	3.6	±1.8	4.0	±2.6		0.255	0.776
TOGT (s)	12.9	±3.6	13.7	±4.6	17.1	±6.5	†	5.087	0.009
TRGT (s)	8.3	±2.3	9.4	±3.4	7.7	±3.4		1.989	0.144
ACGT (s)	4.6	±1.7	4.3	±1.9	9.5	±3.7	† ‡	31.551	0.001
TT (s)	1.2	±0.3	1.5	±0.5	1.4	±0.5		1.376	0.259

Table 3. Comparison of time-motion variables in judo combats by female weight competition categories.

Variable (indicator)	<48 kg (n = 25)		<63 kg (n = 25)		>78 kg (n = 25)			F-value	p-value
TRT (s)	276.7	±124.9	271.0	±149.9	275.1	±138.9		0.011	0.989
TCT (s)	202.2	±88.8	189.9	±96.1	200.5	±94.4		0.129	0.879
PT (s)	7.1	±2.7	7.9	±3.3	7.7	±3.2		0.455	0.636
GCT (s)	5.4	±7.1	5.8	±6.1	2.8	±2.6		2.100	0.130
SE (n)	10.4	±5.3	10.4	±5.6	8.8	±4.3		0.811	0.448
STE (s)	21.8	±9.1	20.6	±6.3	23.1	±6.4		0.681	0.509
DWC (s)	5.1	±2.5	3.2	**±2.1***	3.5	±2.1	†	5.222	0.008
TOGT (s)	9.5	±3.4	10.9	±4.4	15.7	±6.6	†‡	10.834	0.001
TRGT (s)	4.0	±1.7	4.5	±1.8	5.7	±2.2	†‡	5.231	0.008
ACGT (s)	5.5	±2.1	6.4	±2.9	10.1	±5.0	†‡	11.766	0.001
TT (s)	1.4	±0.3	1.4	±0.5	1.2	±0.5		1.337	0.269

longer in men (7.7 ±3.4 s) than in women (5.7 ±2.2 s). In the lightweight category, significant differences were detected in the TOGT, which was higher in men (12.9 ±3.6 s) than in women (9.5 ±3.4 s), and in the time trying to execute *kumi kata* (TRGT), which was also higher in men (8.3 ±2.3 s) than in women (4.0 ±1.7 s). In the middleweight group, there were significant differences between men and women in the TOGT, the TRGT, and the ACGT. Men had longer TOGTs than women (13.7 ±4.6 s vs. 10.9 ±4.4 s, $p < 0.05$) and longer TRGTs (9.4 ±4.5 s vs. 4.5 ±1.8 s, $p < 0.001$), but once the grip had been accomplished, women gripped for longer than men (6.4 ±2.9 s vs. 4.3 ±1.9 s, $p < 0.05$). The TCT was 197.5 ±92 s in the female category, 202.8 ±86.2 s in the male category, and averaged 200.2 ±88.9 s overall (Tables 1 and 2, Figure 1).

DISCUSSION

The 150 matches that were analysed provide a picture of how competitive judo combat is structured at an elite level. This picture is clearly defined by the SE, a very important indicator to our understanding of the temporal structure of judo combat. Consequently, this is also very important for training, with a SE defined as a set of consecutive actions; that is, SE = DWC + TOGT (TRGT + ACGT) + TT + GCT. As observed in our time-motion analysis, each SE had a specific duration (i.e., the STE) that was followed by a pause determined by the referee (i.e., the PT) [6]. Therefore, the judo combat structure can be expressed as (STE + PT) ×(SE), and appeared in most combat, except for the last SE when the referee ends the match (sodemade). Figure 1 summarises the temporal structure observed in this study.

Based on data for the 1996 Olympic Games in Atlanta, Sterkowicz [38] found a TCT of approximately 186 s in the male category and 174 s in the female category. Van Malderen et al. [17] also found an overall average of 152 ±100 s, but a lower average of 87 ±66 s for women when considered in isolation, and Miarka et al. [22] found an average for women of 179 ±135 s. Other authors have presented similar results, but without differentiating between sexes, and have reported TCTs ranging between 172 s and 262 s [14, 33, 35]. The variability in combat times when compared with this study could be due to changes in IJF rules that have aimed to make the sport more technical and attractive for spectators, which may well have made it more difficult to win a match before the established time is up. The weight categories analysis showed that the highest TCT for men (233.3 ±78.2 s) was at the intermediate category and for women (202.2 ±88.8 s) at the lightest weight category. This coincides with the study of Sterkowicz-Przybycien et al. [39] in respect of men but no of women;

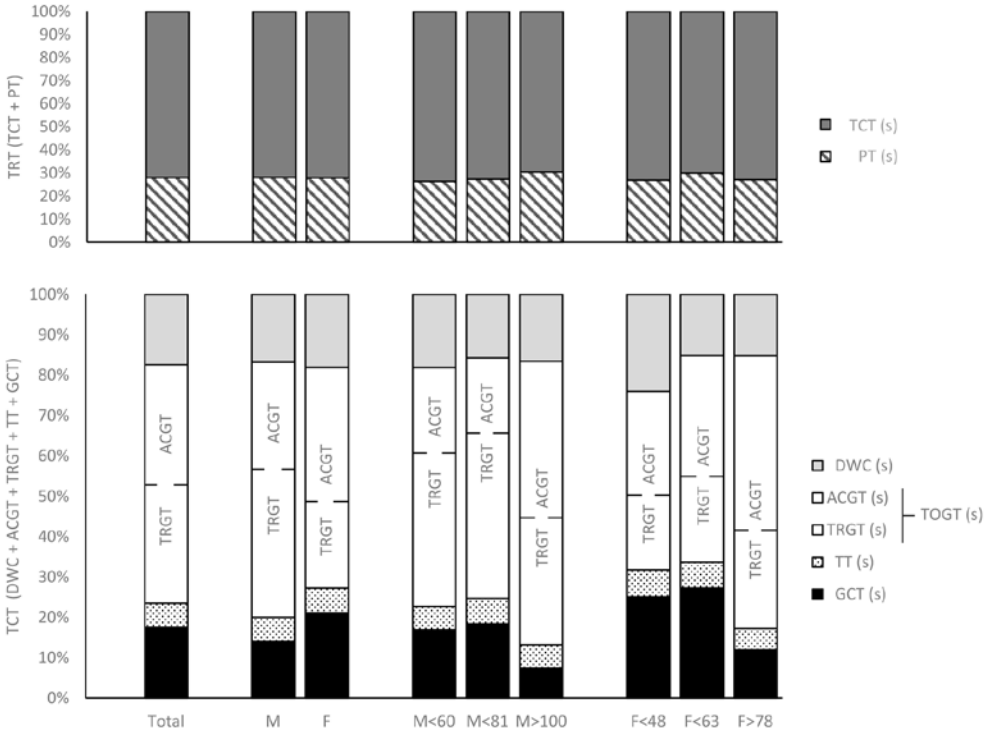

Figure 1. Time distribution in high-level judo combat by sex and weight category.

Abbreviations: **TRT** total real time; **TCT** total combat time; **PT** pause time; **GCT** groundwork combat time (*ne waza*); **DWC** displacement without contact; **TOGT** total gripping time; **TRGT** trying gripping time; **ACGT** accomplished gripping time (*kumi kata*); **TT** throwing time (*nage waza*); **M** males; **F** females.

its results situate the highest TCT for women at the intermediate category also. Moreover, the comparison between the results of both studies revealed considerable differences in TCT.

We found an overall TRT (i.e. the TCT plus the PT) of 278.3 ±133.2 s, which broke down to 274.3 ±136.4 s for women and 282.2 ±130.7 s for men. By contrast in the research by Hernández and Torres [37], the overall average was 284 ±172 s, and the results for women and men were 289 ±209 s and 279 ±144 s respectively. In other studies which did not differentiate between the sexes. Castarlenas and Planas [14] and Sterkowicz and Maslej [35] obtained averages of 273 s and 235.9 respectively. Overall, the results obtained in this study for TRT are comparable with those published in the literature.

The results for the SE variable were also similar to those in previous studies with an average of 9.7 ±4.9 n overall. For example, Sterkowicz and Kesek [33] reported an average of 7.7 n, Sterkowicz and Maslej [35] reported 5.9 n, Calmet et al. [18] reported 9 ±6, and Marcon et al. [19] reported 11 n. We did not find significant differences between men and women, reinforced by the fact that the TCT variable was comparable between both sexes.

The average STE in this study was 22.4 ±7.1 s, a figure comparable to those reported in previous studies: 30 s Sterkowicz and Kesek [33]; 30 s Sikorski et al. [12]; 18 ±9 s Castarlenas and Planas [14]; 25.1 s Sterkowicz and Maslej [35]; 15.8 ±9.5 s Calmet et al. [18] and 30 ±33 s Miarka et al. [6] have reported.

By sex, we obtained an average STE of 21.4 ±7.9 s for men and 20.5 ±8.1 s for women, which were similar to the levels reported by Van Malderen et al. [17], who obtained an average of 18.8 ±9 s for men and 19.9 ±7.3 s for women. They are also similar to the results of Hernández and Torres [25], who found an overall average of 26 ±10 s, with averages of 22 ±4 s for women and 29 ±11 s for men. This similarity could be because, even with regulatory changes, the

temporal structure of the judo fighter has not changed. Also, besides, they are given the same phases within their own STE, globally.

We obtained an average overall PT of 7.9 ±3.2 s, with 7.6 ±3.1 s for women and 8.2 ±3.3 s for men. Van Malderen et al. [17] reported similar results for women (7.5 ±6.2 s) and men (9.1 ±5.1 s). However, Hernández and Torres [25] reported an average of 9 ±4 s, with 12 ±4 s for women and 7 ±2 s for men and Miarka et al. [6] and the average for women of 6 ±7 s. In studies that did not distinguish between sexes, the overall values were higher and comparable to those obtained in the female sample of this study: 12.98 s Sterkowicz & Kesek [33]; 13 s Sikorski et al. [12]; 10 s Sterkowicz & Maslej [34]; 11 ±10 s Miarka et al. [6]. Previous studies have indicated that the duration of the PT increases as a match progresses, with Gorostiaga [2] concluding that this was because judokas voluntarily increase the frequency and duration of PTs. This is supported by the results of Monteiro [34], who showed that the PT was 9.5 ±3.2 s in the first minute of combat, 10.4 ±4.5 s in the second minute, 13.4 ±7.6 s in the third minute, 13.2 ±7.3 s in the fourth minute, and 13.9 ±9 s in the fifth minute. A gradual decrease in the STE accompanied this change in PT. However, Marcon et al. [19] studied 10 judokas during three matches with 20-minute rest intervals between matches, and reported the following PT values: match 1 = 7 ±1 s; match 2 = 6 ±2 s; and match 3 = 7 ±1 s. In the present study, we did not consider whether there was an increase in the PT during the SE. PT is an interesting variable for physical preparation and strategy. Physiologically tells us the characteristics of rest between every judo STE. PT is a time to consider and to train and, therefore, prepare recoveries during combat.

The average for the DWC variable was 3.9 ±2.3 s for each SE and was 3.9 ±2.3 s for men and 4.0 ±2.4 s for women. Very few other studies have analysed this variable. However, Marcon et al. [19] recorded 4 ±1 s per SE. Calmet et al. [18] observed 2.1 ±2.8 s per SE. Miarka et al. [6] obtained a result of 5 ±8 s in the senior age category and Miarka et al. [22] 7 ±6 s for women. The weight categories analysis revealed similar values for each category (from 3.2 s to 4.0 s), except for women belonging to the lightest weight category (5.1 s), which, interestingly, was the value more similar to the results of Sterkowicz-Przybycien et al. [40]. PT and DWC are relevant to decision-making and training opportunities. The time that judokas have before they meet their opponent provide an opportunity to receive instructions from their coach and could be used to tactical and strategic advantage when training for contests. Miarka et al. [6], for example, found that the most expert judokas spent more time in DWC. Also, Calmet et al. [18] considered that this time provided tactical advantages for two possible reasons: 1) it can be used to analyse the opponent and achieve a good grip, and 2) it not only provides opportunities to manage the space but also time to control the opponent. We support these arguments and stress the need to focus on devoting training sessions to improving the management of these times. This should enable judokas to tackle combat situations in competition more effectively by training to make certain decisions in response to a specific opponent type.

In the 150 matches, the average TOGT was 13.3 ±5.6 s for each SE, averaging 14.5 ±5.3 s for men and 12.0 ±5.6 s for women. This is an aspect of judo combat that has not been widely studied. In three successive matches, however, Marcon et al. [19] obtained results of 16 ±5 s, 18 ±3 s, and 17 ±3 s, while Miarka et al. [6] found a value of 14 ±15 s in their senior category. These results were comparable to those of our study. It was also notable that there were significant differences ($p<0.05$) between the sexes in the TOGT for the lightweight category, with an approximate difference of 2.5 s. This could be due to the higher number of SEs in the lightweight female group, possibly as a result of a greater number of throwing attacks (*nage waza*); this is plausible given that more attacks would reduce the gripping time (*kumi kata*) and thereby increase the total number of SE. When comparing the weight categories among women, it was also noted that heavyweight female judokas spent longer fighting to execute a grip (TRGT) or gripping with two hands (ACGT) than in either the lightweight or mediumweight categories. This could be important in the planning of the technical-tactical and conditioning training for the heavyweight category, where a greater focus should be placed on training for TOGT. Indeed, the importance of this is emphasised by the fact that, of the average, the STE duration of 23.1

±6.4 s in the heavyweight category, 15.7 ±6.6 s was spent in TOGT (i.e. 67.9% of the STE).

In relation to the gripping time, we proposed two new variables (TRGT and ACGT). The sum of these variables was the TOGT:

• TRGT: the average TRGT was 6.6 ±3.2 s, which could be broken down to 4.7 ±2.0 s for women and 8.4 ±3.1 s for men, showing a marked difference (almost double) between the sexes. The analysis by sex and weight category also revealed significant differences between the lightweight categories for men and women, and between the mediumweight categories for men and women. These differences, with a lower TRGT in women, could be due to the greater speed at which *kumi kata* is executed in these two female weight categories, with women in these categories taking less time to grip their opponent with two hands than men in equivalent categories. It could be that judokas in these two male weight categories spend longer trying to grip as they are less likely to accept being dominated, and therefore break the *kumi kata* and fight for it again. Calmet et al. [19] found that the average time to achieve a full grip was 6.3 ±7.8 s for expert judokas.

• ACGT: the average ACGT was 6.7 ±3.8 s, that for women was 7.3 ±4.0 s, and that for men was 6.1 ±3.5 s. Significant differences ($p<0.05$) were found between the sexes in the middleweight categories, possibly because of men in this weight category attack much faster when they are gripping with two hands than women in the corresponding weight category. The statistical analyses of male and female categories independently revealed significant differences within both sexes. In the male category, there were differences between the heavyweight and the other weight categories, with the time from achieving *kumi kata* to throwing the opponent (*nage waza*) being considerably longer in the heavyweight category than in either the middleweight or lightweight categories. Thus, judokas in the heavyweight category were not as fast in this respect. In the female category, there were also significant differences in this variable between the heavyweight and the other weight categories, with heavyweight judokas being slower at attacking after achieving a grip with two hands.

The overall TT per SE was 1.3 ±0.5 s. In three matches. Marcon et al. [19] found very similar results to those obtained in this study (Match 1 = 1.4 ±0.3 s; Match 2 = 1 ±0.4 s; and Match 3 = 1.7 ±0.5 s). Elsewhere, Calmet et al. [18] reported average TTs per SE of 1.1 ±1.4 s for expert judokas, 2 ±2 s for intermediate-level judokas, and 2.6 ±2.3 s for beginners. The overall results for GCT per SE were 3.9 ±2.6 s, with times of 4.6 ±2.7 s for women and 3.2 ±2.0 s for men. Comparable to this, Marcon et al. [19] recorded times of 6 ±4 s. 4 ±2 s, and 5 ±2 s in three consecutive matches. They also reported that groundwork SE lasted 17 ±12 s, 9 ±5 s, and 13 ±6 s, respectively. In other research Castarlenas and Planas [14] observed an average of three groundwork SEs per match, with an average length of 18 s per SE. The results for this indicator obtained by Miarka et al. [6] were 15 ±14 s and by Miarka et al. [22] 8 ±9 s. The weight categories analysis showed the lowest values of GCT at the heaviest weight category (2.8 ±2.6 s for women and 1.8 ±1.2 s for men), when the results of Sterkowicz-Przybycien et al. [40] situate the lowest values of GCT at the lightest weight category for men (1.8 s) and the intermediate category for women (2.4 s). We conclude that, when planning groundwork (*ne waza*) training, it will be important to consider the total groundwork time per SE, as stated in the literature, and to use the SE structure proposed in this study (SE = DWC + TOGT (TRGT + ACGT) + TT + GCT) as an illustration of what happens before *ne waza* is achieved. If this structure is not considered, at least in part of the training, there is the risk that judokas will not be sufficiently specific with their groundwork in elite, competitive judo combat.

CONCLUSIONS

Our results indicate that there are differences between some weight categories in the same and the opposite sex in several time variables, particularly those related to *kumi kata*. The sum of the PT plus the DWC was approximately 12 s, which we consider an important window for decision-making at the start of the SE during matches, and which should be targeted in training and development. The periods between fighting sequences can be used by coaches and judokas to improve their strategic approach and thereby enhance their management of the different combat times. To optimise the training of elite judokas by sex and weight category, we recommend adopting the technical-tactical and conditioning training

associated with *kumi kata* to the results obtained in this study, particularly in relation to the TRGT and ACGT variables, which should be treated as different aspects of the TOGT.

HIGHLIGHTS

- Several distinctions can be observed in terms of weight categories and sex regarding the *kumi kata* time: coaches should consider these in the planning of the workouts.
- An approximate 12 s pause time has been observed between *matte* and *hajime*. This period should be employed by judokas to determine a decision-making plan for the continuation of the combat.
- It is necessary to analyse the *kumi kata* according to TRGT and ACGT situations, which will allow specific training to optimise the effectiveness of *nage-waza* techniques.

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