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COACHING & KINESIOLOGY

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Technical report on a time-motion analysis of male judo cadets' combats between weight divisions

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Key words: motor control, strength, task performance and analysis, martial arts, resistance training, athletic performance

Abstract
Methods. Time-motion analysis data of cadet-athletes (age: 15.95 ± 0.68 years-old) were grouped by weight divisions, according to the following criteria: lightweight *Lighters* (n = 224 combats of -50kg, -55kg and -60kg), middleweight *Middlers* (n = 76 combats of -66kg, -73kg and -81kg) and heavyweight *Heavies* (n = 50 combats of -90kg and +90kg) at four state judo championships. Total and sequential time-motion analyses were observed, according to each combat phase (i.e. standing combat, approach, gripping, attack, groundwork combat, and pause phases) and compared by weight divisions, $p \leq 0.05$.
Results. The main results indicated significant differences between combat time, with lightweight *Lighters* (234.4s ± 122.3s) > middleweight *Middlers* (191.6s ± 118.2s) and heavyweight competitors *Heavies* (176.8s ± 131s), standing combat time, with *Lighters* (125.4s ± 67.4s) > *Middlers* (99.6s ± 70.8s) and *Heavies* (91.1s ± 63.6s), approach phase, with *Lighters* (41.5s ± 26s) > *Middlers* (27.2s ± 18.2s) and gripping phase, with *Lighters* (75.5s ± 49.2s) >Heavies (51.3s ± 36.9s).
Conclusions. Our results suggest that individual training programs should be adjusted for cadets according to their weight divisions with consideration given to the temporal structure of the competitive environment.

Introduction

Performance analysis in judo reveals a variety of movements with different intensities and constant interruptions during a match which clearly defines the intermittent nature of the combat sport. Investigations regarding time-motion analysis in competitive judo demonstrated combat sequences lasting about 30s followed by pauses of ~10s [Brito *et al*. 2017; Franchini *et al*. 2013]. These findings have allowed practitioners and researchers to make inferences about the physiological demands of senior judo athletes [Branco *et al*. 2013; Franchini *et al*. 2019], create sport-specific assessments [Helm *et al*. 2018] and comparable training sessions [Toronjo-Hornillo *et al*. 2018; Vasconcelos *et al*. 2020]. However, cadets' weight-category specific time-motion and technical-tactical strategies in judo are empirically known [Coswig *et al*. 2018], no study has examined the differences between weight divisions in men during competition with a representative sample. This information has a significant impact concerning the need analyses required in the advance of both general and sport-specific training programs for cadet-athletes.

Although combat and pause phases have been measured in elite-level judo tournaments [Miarka, Brito *et al*. 2018] and may be used to provide generic work to rest ratio recommendations for training, the evaluation of combat sub-phases in cadet-athletes is limited both for the accumulated duration throughout the match and the time to complete sequential activities [Miarka *et al*. 2014]. This evidence, including technical-tactical data, would allow strength and conditioning professionals to prepare further personalized sport-specific interval training programs, according to weight divisions. With consideration for the population-specific differences in time-motion analysis variables during judo cadet competitions and to enhance contemporary knowledge on the topic of training program design, the present study aimed to compare the phases of combat in male cadet judo athletes across different weight categories. Therefore, what are the differences between the weight divisions of *judo* male cadet-athletes?

We hypothesized that lightweight *lighters*, middleweight *middlers*, and heavyweight competitors will show differences regarding the technical-tactical aspects analyzed, specifically, middleweight categories are more homogeneous and, for this reason, could show a long time between the execution of the grip until the attack. Heavy *judo* athletes, hypothetically, would have shorter combat associated with athletes' anthropometric heterogeneity while lightweight athletes could have a longer approach time between the pause and the gripping moment, as a specific strategy of analyzing the opponent's movements.

Methods

Sample

For the purpose of analyses, time-motion analysis data of cadet-athletes (aged: 15.95 ± 0.68) were grouped by weight divisions according to the following criteria: *Lighters* (n = 224 combats of -50kg, -55kg and -60kg), *Middlers* (n = 76, combats of -66kg, -73kg and -81kg) and *Heavies* (n = 50 combats of -90kg and + 90kg) of four state judo championships. To be included, each video had to be of sufficient quality (standard definition 480/60i) and taken from a landscape view of the entire competition area. The competitive bouts were evaluated following previously outlined protocols [Miarka *et al*. 2017], from four local competitions realized in 2018 between April and August. The computer version of VirtualDub Program 1.8.6(2) was used to fragment and edit images and Frami® software was used to conduct the time-motion analysis; the study was previously approved by the Federal University of Juiz de Fora Ethics and Research Committee (n. 68598317.0.0000.5147), according to WMA Declaration of Helsinki.

Analysis of time-motion patterns and reliability testing

The reliability measures were assessed through intra-observer and inter-observer testing procedures on time-motion data provided by two experts, with more than ten years of judo experience and university degrees in Physical Education, who analyzed *judo* matches with FRAMI software [Dal Bello *et al*. 2019]. Briefly, for inter-observer agreement, the first expert analyzed 20 performances of athletes and the second expert analyzed the same 20 athletes. After this procedure, the second expert performed the intra-observer agreement, with the selection of the 10 combats (20 athletes) in a randomized order, before repeating the analysis an additional time [Miarka, Dal Bello *et al*. 2018]. The reliability of this software was examined using Cohen's Kappa. From the distribution for each variable, the following Kappa values and strength of agreement classifications were used: 0.0 to 0.2, poor; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, substantial; 0.81 to 1.00, almost perfect. The index and classification of Kappa values of combat/pause phases analysis used in the present study for Inter-expert and Intra-expert measurements were 0.74 and 0.82, classified as "Strong" and "Almost perfect" for Approach Phase, 0.45 and 0.96, classified as "Moderate" and "Almost perfect" for Gripping Phase, 0.52 and 0.97, classified as "Moderate" and "Almost perfect" for Attack Phase, 0.84 and 0.90, classified as "Almost perfect" and "Almost perfect" for Groundwork Phase and 0.91 and 0.99, classified as "Almost perfect" and "Almost perfect" for Pause Phase, following preceding reports [Lopez Diaz-de-Durana *et al*. 2018].

Table 1. Total time of male judo cadet combats separated by weight divisions.

Time-motion variables	Time/combat (seconds)					p-values		
	Weight divison	**Mean±SD**	**F**	**Sig.**	**ES**	**≠1**	**≠2**	**≠3**
Combat	Lighters	234.4±122.3	4.963	.008	.035		.046	.044
	Middlers	191.6±118.2						
	Heavies	176.8±131.0						
	Total	217.3±124.1						
Standing combat (*tachi-waza*)	Lighters	125.4±67.4	5.805	.003	.041		.025	.027
	Middlers	99.6±70.8						
	Heavies	91.1±63.6						
	Total	115.2±69.0						
Approach	Lighters	41.5±26.0	8.498	.000	.059		≤.001	
	Middlers	27.2±18.2						
	Heavies	32.7±31.4						
	Total	37.0±25.7						
Gripping (*kumi-kata)*	Lighters	75.5±49.2	3.362	.036	.024			.043
	Middlers	65.9±60.8						
	Heavies	51.3±36.9						
	Total	70.4±51.5						
Attack	Lighters	6.2±4.8	1.280	.280	.009			
	Middlers	5.9±4.7						
	Heavies	4.8±5.2						
	Total	6.0±4.9						
Groundwork combat (*ne-waza*)	Lighters	46.1±29.0	.655	.520	.005			
	Middlers	46.7±39.0						
	Heavies	39.5±26.7						
	Total	45.5±31.4						
Pause	Lighters	61.6±51.5	3.454	.033	.025			
	Middlers	45.2±41.2						
	Heavies	44.9±57.7						
	Total	55.7±50.4						

Note: time presented by second/combat. F= F calculated, Sig.= significance, ES= effect size.

Statistical Analysis

Kolmogorov-Smirnov test (K-S) was used to determine the data's normal distribution. Descriptive data are presented as mean and standard deviation (SD) values. ANOVA One-way followed by Bonferroni post-hoc tests were conducted to compare time-motion differences between weight categories. Eta-squared (ES) was used to verify the effect size and the significance level of $p \leq .05$ was used. All analyses were conducted using SPSS 20.0 for Windows.

Results

Table 1 shows descriptive and comparisons of time-motion analysis of each combat phase between weight divisions.

Table 2 shows descriptive and comparisons of each sequential time of combat phases between weight divisions of judo cadet-athletes.

Discussion

We compared the phases of judo combats in male cadet-athletes separated into four weight divisions. Our results showed large differential effects by the weight category of male cadets on phases of combat in judo. The lightweight competitors (*Lighters*) had a longer combat time in standing combat realizing displacements and gripping attempts than others. While *Heavies* demonstrated shorter gripping time than lightweight competitors (*Lighters*). In the sequential time-motion analysis, a main significant difference was observed in standing combat with a long time of *Lighters* than the *Heavies*. The currently reported approach and gripping times are shorter than those in the extant literature for senior competitors (approach: 5-8s; gripping: 6-13s) [Calmet *et al*. 2010; Miarka *et al*. 2014]. The current results indicate that lightweight competitors (*Lighters*) may adopt the previously reported strategy of extending the time spent gripping to maintain dominant positioning and delay attacks until later in the match or prompt

Table 2. Total time of male weight divisions separated by combat phase ratio.

Time-motion variables	Time/combat phase					p-values		
	Weight divison	**Mean±SD**	**F**	**Sig.**	**ES**	**≠1**	**≠2**	**≠3**
Combat	Lighters	27.9±7.8	1.466	.233	.011			
	Middlers	29.1±10.2						
	Heavies	30.8±16.0						
	Total	28.5±9.7						
Standing combat (*tachi-waza*)	Lighters	20.0±10.8	3.062	.048	.022			.05
	Middlers	22.0±11.3						
	Heavies	25.6±18.4						
	Total	21.2±12.1						
Approach	Lighters	5.0±2.0	2.057	.13	.015			
	Middlers	4.6±1.9						
	Heavies	5.6±3.2						
	Total	5.0±2.2						
Gripping (*kumi-katá)*	Lighters	7.6±4.4	2.057	.13	.015			
	Middlers	5.7±4.2						
	Heavies	5.6±5.7						
	Total	6.9±4.6						
Attack	Lighters	1.1±0.8	1.609	.202	.012			
	Middlers	1.0±0.5						
	Heavies	0.9±0.5						
	Total	1.0±0.7						
Groundwork combat (*ne-waza*)	Lighters	8.8±4.5	2.473	.086	.018			
	Middlers	9.4±4.9						
	Heavies	10.9±6.5						
	Total	9.2±4.9						
Pause	Lighters	7.5±3.5	.072	.93	.001			
	Middlers	7.4±5.6						
	Heavies	7.2±3.9						
	Total	7.4±4.1						

Note: time presented by second/combat phase sequence. F= F calculated, Sig.= significance, ES= effect size.

penalties to be committed by their opponents [Courel *et al*. 2014; Escobar-Molina *et al*. 2014], whereas *Heavies* may not demonstrate a large gripping frequently alter their patterns to engage their opponents, as the other two groups [Escobar-Molina *et al*. 2014; Miarka *et al*. 2012]. However, varying throwing techniques while maintaining consistent grip positions are likely to be beneficial for all athletes regardless of weight division [Escobar-Molina *et al*. 2014]. In support, Kajmovic *et al*. [2014] reported that contact with the judo uniform (*judogi*) most often occurred on the chest (lapel). Nonetheless, a higher focus on tactical strategies during the approach and gripping phases may be required for heavyweight male cadet-athletes.

Lightweight competitors (*Lighters*) and middleweight competitors (*Middlers*) have lower body fat percentages than those in the heavier divisions [Sterkowicz-Przybycien, Almansba 2011]. As strength relative to lean body mass tends to be inversely related to body size, the lightest athletes may exhibit a greater anaerobic power to weight ratio [Franchini *et al*. 2011]. In the heaviest division, the highest body fat percentages and the lowest relative strength are displayed when compared to other divisions [Sterkowicz-Przybycien, Almansba 2011]. Thus, unique phenotypes and physical qualities amongst athletes in the lowest and highest categories may have precluded potential differences in gripping and attack phases of combat. Using a biomechanical approach to classify judo throws, Sterkowicz *et al*. [2013] showed a higher frequency of specific throwing techniques in a male lightweight category when compared to heavier weight divisions.

The variation in temporality amongst the weight in cadet divisions may be the result of two causes: 1) inequality of physical fitness and/or 2) the tactical response to being penalized, which has shown to be a factor in the competitive outcome of judo matches, particularly in heavyweight athletes [Courel *et al*. 2014]. Despite differences in the temporal structure of judo competition between weight categories, normative values for judo-specific fitness have been limited to weight and competitive level distinctions [Franchini *et al*. 2011; Sterkowicz-Przybycien, Fukuda 2014]. With limited data available on the match demands across weight divisions

in judo, the results of this study provide information regarding the unique distribution of combat phases by weight in cadet males during judo competition. This study highlights the need to consider both the accumulated and sequential combat and pause times during time-motion analysis. While both accumulated combat/pause times and the duration of sequential pauses and combat actions tended to be similar between light-weight competitors (*lighters*) and middleweight (*middlers)* athletes, differences in combat sub-phases were apparent. Thus, interpretation of cadet weight-division specific combat sub-phase data is likely to differ according to the analysis of accumulated time versus the duration of each sequential combat action.

Conclusion

The temporal characteristics reported in this study, including the duration of a given combat/pause action and the accumulated duration throughout a judo match, provide information that can be used in both program design and the manipulation of training variables of cadets. Using the data provided in this technical report, trainers/coaches might choose to develop training sessions aimed at improving both technical-tactical skills as well as sport-specific conditioning. Weight-specific work-to-rest ratios, developed from the differences in gripping and attack values, should be considered when structuring conditioning drills. The lightest and heaviest competitors displayed unique characteristics, compared to athletes in the other divisions, suggesting the use of training groups primarily composed of these cadet-athletes. For example, to a higher accumulated time in the gripping phase, it may be appropriate for male lightweight and middleweight athletes to devote a larger period of the technical training session on extended duration gripping patterns. Thus, individual training programs should be adjusted for athletes according to their weight division with consideration for the temporal structure of the competitive environment. Finally, normative data for *judo*-specific fitness should be devised for each division.

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Raport techniczny z analizy czasowo-ruchowej w walkach judo kadetów płci męskiej w różnych kategoriach wagowych

Słowa kluczowe: kontrola motoryczna, siła, wykonywanie i analiza zadań, sztuki walki, trening oporowy, wyniki sportowe

Streszczenie

Tło. Schematyczna analiza ruchu w czasie dla zawodników kadetów jest potencjalnym mediatorem sukcesu i może pomóc w rozwoju treningu judo.

Problem i cel. W niniejszym badaniu porównano fazy walk judo u kadetów-sportowców płci męskiej w różnych kategoriach wagowych.

Metody. Dane analizy ruchu w czasie kadetów-sportowców (wiek: 15,95 ± 0,68 lat) pogrupowano według kategorii wagowych, według następujących kryteriów: waga lekka (n = 224 walki -50 kg, -55 kg i -60 kg), średnia (n = 76 walk z wagami -66kg, -73kg i -81kg) oraz ciężka (n = 50 walk z wagami -90kg i +90kg) w czasie czterech stanowych mistrzostw w judo. Obserwowano całkowitą i sekwencyjną analizę ruchu w czasie, zgodnie z każdą fazą walki (tj. walka w pozycji stojącej, zbliżanie się, chwytanie, atak, walka w parterze i faza pauzy) i porównywano je w podziale wagowym, $p \leq 0,05$.

Wyniki. Główne wyniki wskazują na istotne różnice między czasem walki zawodników wagi lekkiej (234,4s ± 122,3s) > średniej (191,6s ± 118,2s) i ciężkiej (176,8s ± 131s), czasem walki stojącej u zawodników wagi lekkiej (125,4s ±67,4s) > średniej (99,6 s ± 70,8 s) i ciężkiej (91,1 s ± 63,6 s), fazą zbliżania, u zawodników wagi lekkiej (41,5 s ± 26 s) > średniej (27,2 s ± 18,2 s) i faza chwytania u zawodników wagi lekkiej (75,5 s ± 49,2 s) >ciężkiej (51,3s ± 36,9s).

Wnioski. Wyniki autorów sugerują, że indywidualne programy treningowe powinny być dostosowywane dla kadetów zgodnie z ich podziałami wagowymi, z uwzględnieniem czasowej struktury środowiska rywalizacji.