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Original Article

Characteristics of Handgrip (Kumi-Kata) Profile of Georgian Elite Judo Athletes

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Abstract

The study investigated the characteristics of kumi-kata in elite judokas on kinematic and temporal parameters of different types of handgrip (HG). *Methods:* fourteen participated in this study male athletes (23.5±2.61 years; 1.81±0.37 0 m; 87.25±22.75 kg), members of the Georgian Judo team. To characterize the dominance and types of kumi-kata were analysed, and to characterize kinematic and temporal parameters and handgrip. *Results:* The values of 0.26±0.69s and 0.31±0.03s for reaction time were obtained, respectively, in the full grip and pinch grip; 19.62±18.83N/cm/s and 6.17±3.48N/cm/s for the rate of force development; 475,21 ± 101,322 and 494,65±112,73 and FDR 1,45 ± 0,824s for the time between the force onset to the TFP; and 41,27±4,54N/cm/s. There was no significant difference variable, except for the dominance of kumi-kata ($p<0.05$) used in combat. *Conclusion:* The dominance kumi-kata is a technical option, as it does not depend on the kinetic-temporal parameters of handgrip.

1. Introduction

Judo is a martial art and an Olympic sport that was created as a physical (Fukuda, Stout, Burris, & Fukuda, 2011), intellectual and moral education method in Japan (Matsumoto, 1996), determined by technical-tactical skills has fundamental ties to strength and conditioning (Franchini, Ferreira Julio, Matheus, & Candau, 2015; Fukuda et al., 2011). The *kumi-kata* or grip is an essential foundation for the judoka (Osipov, Kudryavtsev, Iermakov, & Jagiełło, 2017), providing the first contact between two athletes in a fight and the basic support for

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implementing other techniques(Soriano et al., 2019). This technique enables the opponent's control during defensive and offensive actions, being essential for the successful application of blows (Osipov et al., 2017), which demonstrates the importance of an adequate muscle function for this specific movement (Adel et al., 2019; Gleeson & Mercer, 1996). In this sense, the *kumi-kata* consists of a handgrip judo skill, in which the ability to effectively generate force through the hands and fingers is crucial(Brito et al., 2005). When analyzing high-level international competitions, they found that the time of force application during the *kumi-kata* rarely exceeds 30’s (Calmet, Miarka, & Franchini, 2010),also 14 to 15s’ are sufficient to reach the maximum handgrip strength on the clothing of the adversary (*Judogi*) (Calmet et al., 2010; Castarlenas, & Planas i Anzano, 1997; Miarka et al., 2012). However, these authors found that during a combat, the total time to perform the *kumi-kata* is (89±93)s. This means that the *Kumi-Kata* is applied for almost 30% of combat time (Belkadi et al., 2015; Benhammou, Mourot, Mokkedes, Bengoua, & Belkadi, 2021; Yahia, 2020). In the study by Calmet et al. (2010), it was observed that experienced athletes use less time between the contact of the grip and the applied technique compared to beginners. Furthermore, to respond efficiently to opposing actions, it is required that the athlete's force production be fast and the reaction time be low (Sirico et al., 2020; Zaggelidis, & Lazaridis, 2013). However, when offensive and defensive actions are not effectively performed in a short period of time, the isometric strength resistance becomes important for the opponent's control (La Bounty, Campbell, Galvan, Cooke, & Antonio, 2011; Suchomel, Nimphius, & Stone, 2016). as the reaction time (RT), the rate of force development (TDF), the peak force (PF), the time between the force onset to the PF (TOP) and the fall index (IQ), are of great importance for the efficiency of the actions performed by the judoka during combat (Ache Dias et al., 2012; Detanico, Arins, Dal Pupo, & Dos Santos, 2012; Detanico, Dal Pupo, Franchini, & Dos Santos, 2015). Recent studies have sought to characterize the peak handgrip strength in athletes of different modalities (Ache Dias et al., 2012; Bonitch-Góngora, Bonitch-Domínguez, Padial, & Feriche, 2012), including judo athletes, considering gender, body mass, age, type of training and limb dominance, in order to support a specific assessment of the *kumi-kata* (Ache Dias et al., 2012; Adel, Alia, & Mohammed, 2020; Bonitch-Góngora et al., 2012; Detanico, Kons, Fukuda, & Teixeira, 2020). However, these authors evaluated only one type of handgrip (full palm). Thus, parameters such as TR, TDF, TOP and handgrip IQ, which are relevant to understanding the ability of elite judokas to effectively perform handgrip strength, are still little explored in the literature (Ache Dias et al., 2012; Detanico et al., 2020; Sterkowicz et al., 2016). Additionally, analysis of the grip technique used during official Judo combats, checking the different types of grip, frequency of use and place of application in *judogi*, are even more scarce. Obtaining this information can contribute to directing the specific training of gripping techniques in judo athletes.

Given the above, this study aimed to investigate the characteristics of handgrip in elite Georgian judo athletes. In this way, two main objectives were carried out: (i) to identify which types of grip are most used, the places of the judogi where they are used and the frequency with which they occur, in the dominant and non-dominant upper limb, during official judo combats; (ii) compare parameters related to the force-time curve, from different types of handgrip, in the dominant and non-dominant upper limb.

2. Material and methods

Participants

Fourteen male Judo athletes participated in the study (age 25 ± 2.61 years; height 177 ± 10 cm; body mass 88.38 ± 26.71 kg), black belt (minimum of 14 years of practice and 20 hours of training per week), members of Georgian team by the Georgian Judo federation (GJF) in preparation for the Tokyo 2020 Olympic Games. The sample represented 28.57% of the national of athletes that made up the Georgian team, consisting of about 2 athlete per weight category, while the national team it is made up of approximately 4 athletes per weight category, thus totalling around 28 athletes. The research objectives and procedures were explained to each participant, who read and signed a consent form before the experiment. All procedures were approved by the Research Ethics Committee of the Institute of physical education and sports – RECIPES (Process nº 219/2020) and in accordance with the Helsinki declaration (Association, 2001).

Procedure

To characterize the actions of the hands and the types of handgrip used, a video recording was made during fight training sessions focusing on the athletes' hands. The last 3 international tournaments of each athlete were also analysed. In the analysed training videos, it was possible to identify which type of grip each athlete used when holding the opponent's judogi, for the dominant and non-dominant hand. In the competition videos, it was possible to identify how many times the athlete took a certain location from the opponent's judogi and with which hand he performed the action. In possession of the data from the training and competition videos, it was possible to cross them to obtain a percentage quantification of the use of each type of handgrip, for each athlete, in the dominant and non-dominant hand. The analysis of the training videos was supervised by an expert (Adel et al., 2019) in affordance and hand-object interaction. To measure handgrip strength, two dynamometers were used, developed at the Instrumentation Laboratory (Adel et al., 2019). The measurement of the palm gripping force was performed by means of a "ring" load cell, and the gripper grip force by means of an "S" load cell. The dynamometers were previously calibrated, both with a load limit of 900 N and an excellent linearity coefficient (R^2=0.999; error <0.1%). The analysis of handgrip strength was performed using the protocol of the American Society of Hand Therapists (ASHT) (Bohannon, Peolsson, Massy-Westropp, Desrosiers, & Bear-Lehman, 2006), with seated athletes position in a chair without arm support, with the spine erect and with the knees flexed at a 90° angle. The shoulder was positioned in adduction and neutral rotation, with the elbow flexed at 90°, forearm and wrist in a neutral position, with the possibility of movement up to 30° of extension. The arm was kept in suspension, with the hand fixed to the dynamometer, which was held by the evaluator for the evaluation, and in the grip of the forceps, the dynamometer was fixed to a support with height adjustment. The size of the handle was fixed at 5.5 cm (Ruiz-Ruiz, Mesa, Gutiérrez, & Castillo, 2002) for palm grip and 10 mm for pinch grip (Keir, Bach, & Rempel, 1998; Kozin, Porter, Clark, & Thoder, 1999), as this measure corresponds to the dimension in which the judogi sleeve is configured (Adel et al., 2020; Berguer, Gerber, Kilpatrick, Remler, & Beckley, 1999). The collection was performed over a period of 30s' for each hand, at a frequency of 1000 Hz, with a signal being issued on a computer screen (Vassin Zenati, Belkadi, & Benbernou, 2021), indicating for the subject to press the dynamometer until another signal is issued, to stop pressing the dynamometer (Bassey, & Short, 1990; Hsu et al., 2011). All volunteers were instructed to perform the grip as quickly as possible, and with as much force as possible, as soon as they observed the visual signal (Hilty, Jäncke, Luechinger, Boutellier, & Lutz, 2011; Mohammed, Bachir, Eddine, & Adel, 2018; Mokhtar et al., 2019). During collection, the subjects did not receive visual feedback and received verbal encouragement from the evaluator. The evaluation was carried out in three attempts, interspersed between the dominant and non-dominant hand, in a randomized order. The force signals were processed using a routine developed in a Matlab® environment (v.7.10.0, MathWorks inc., USA) where the data were previously filtered with a 4th order Butterworth low-pass filter with a cutoff frequency of 6 Hz , as verified as the best cut-off frequency through a residual analysis (James, & Wixted, 2011). Data were normalized by forearm circumference, as standardized by (Belkadi, Benchehida, Benbernou, & Sebbane, 2019; Bohannon et al., 2006; Lalia, Ali, Adel, Asli, & Othman, 2019) . The grip onset was verified by the point at which the force reached 2 standard deviations (SD) above the zero value at baseline and the end of the test determined after 30s' elapsed. The variables analysed were the following: (1) Reaction Time (RT, Time between visual stimulus and Force onset); (2) Time from onset to peak (TPP, Time between onset and peak power); (3) Peak Force (PF, Maximum force value observed in the test); (4) Mean Force Development Rate (Mean MFDR values found at each slope of 50 samples from onset to Peak Force) Eq.(1); (5) Strength Development Rate in 200ms (FDR200, Average of the FDR values found at each slope of 50 samples of the Grip start up to 200ms); (6) Peak Force Development Rate in 200ms

Statistical analysis

After verifying the normality of data distribution (Shapiro-Wilk test), the t-test for paired samples (parametric data) and the Wilcoxon test (non-parametric data) were performed for the comparisons of dependent variables between the dominant hands and non-dominant of each type of handgrip. For the correlations between the circumference of the forearm and the peak of strength obtained in each type of grip, the Pearson correlation coefficient for data with normal distribution was used. The sample calculation showed that this study with a sample composed of 18 athletes is 86% powerful in detecting correlation coefficients (r) greater than or equal to 0.7; effect sizes greater than or equal to 1.16 in the parametric t test for paired samples; and effect sizes superior than or equal to 1.19 in the Wilcoxon nonparametric test.

For all procedures, the significance of $p < 0.05$ was considered. For the analyses, the SPSS software, version 22.0 was used and to calculate the power of the statistical tests and effect size as a function of the sample size, the G*Power is a tool to compute statistical power analyses for many different t tests was used.

3. Results and Discussions

Regarding the objective of our study, all identified forms of grip showed a significant difference in their use by the dominant and non-dominant hands when analyzed with the Wilcoxon Test, as can be seen in table 1 above. The third specific objective is to verify the difference between the parameters of the Force x Time curve of the forms of grip identified between the dominant and non-dominant hand. The results of the T-test for paired data in parametric data and the Wilcoxon test in non-parametric data show that the only parameter that showed a significant difference between the dominant and non-dominant hands was the fall index (IQ), as shown in the (table 3), together with the descriptive statistics of the data.

Table 1. *Descriptive statistics of the parameters of the Force x Time curve of the identified gripping forms, results of the T Test for paired data and Wilcoxon Test*

		Dominante (mean ± SD)	**Non dominante (mean ± SD)**	**T**	**p**
Palmar-Plena grip	FMAX(FDR) (N)	475,21 ± 101,322	494,65 ± 112,73	-0,279	0,788
	RT (s)	0,268 ± 0,69	0,313 ± 0,03	-0,28	0,779
	TPP (s)	1,37 ± 0,521	1,45 ± 0,824	-0,278	0,789
	TPF(N/s)	1031, ± 236,15	1279,6± 365,03	-0,28	0,779
	IQ (%)	41 ,27 ± 4 ,54	45,16 ± 5,64	-2,678	0,032 *
Digito-Palmar grip	FMAX(FDR) (N)	95,14 ± 18,286	92,73 ± 18,882	0,661	0,529
	RT (s)	0,54 ± 0,173	0,38 ± 0,038	-0,316	0,761
	TPP (s)	1,75 ± 0,253	2,67 ± 1,94	-1,988	0,087
	TPF (N/s)	287,56 ± 155,15	266 ,41 ± 197 ,74	0,137	0,895
	IQ (%)	44 ,86 ± 2,88	48,11 ± 6,78	-1,655	0,142

Note. * Significant for $p < 0.05$

Through the analysis of the videos, it was verified that the athletes perform the kumi-kata in basically four different places in the opponent's judogi: 1) on the necks, using the full Palmar-Plena grip; 2) on the back, both above and below the opponent's arm, using the Digito-Palmar grip; 3) in the belt, both above and below the opponent's arm, also using the Digito-Palmar grip; and 4) in the sleeves grip, using the Association between Digit-Palmar and Lateral Pinch grips (DPLPG).

The percentages of use of the types of grip identified in the dominant and non-dominant hand are shown in (Table 2). The use of the Palmar-Plena grip was superior in the dominant hand than in the non-dominant hand (p=0.021).

The Digito-Palmar grip was more used in the non-dominant hand (p=0.032). There was also a difference in the use of the DLPG grip, with the use being greater in the non-dominant hand (p=0.012).

Table 2. *Use of different types of handgrip*

	Dominant (%)	Non dominant (%)
full Palmar-Plena grip	69,13 (22.91)*	#8.7 (6.25; 51.85)
Digito-Palmar grip	30,87 (22.91)*	0.0
DPLPG	0.0*	#88.7 (48.15; 93.75)

Note : *p < 0.05. Association between Digit-Palmar and Pinça-Lateral (ADPPL); #Data with non-normal distribution. Normal data are presented as mean (SD) and non-normal data as median (25;75th percentile).

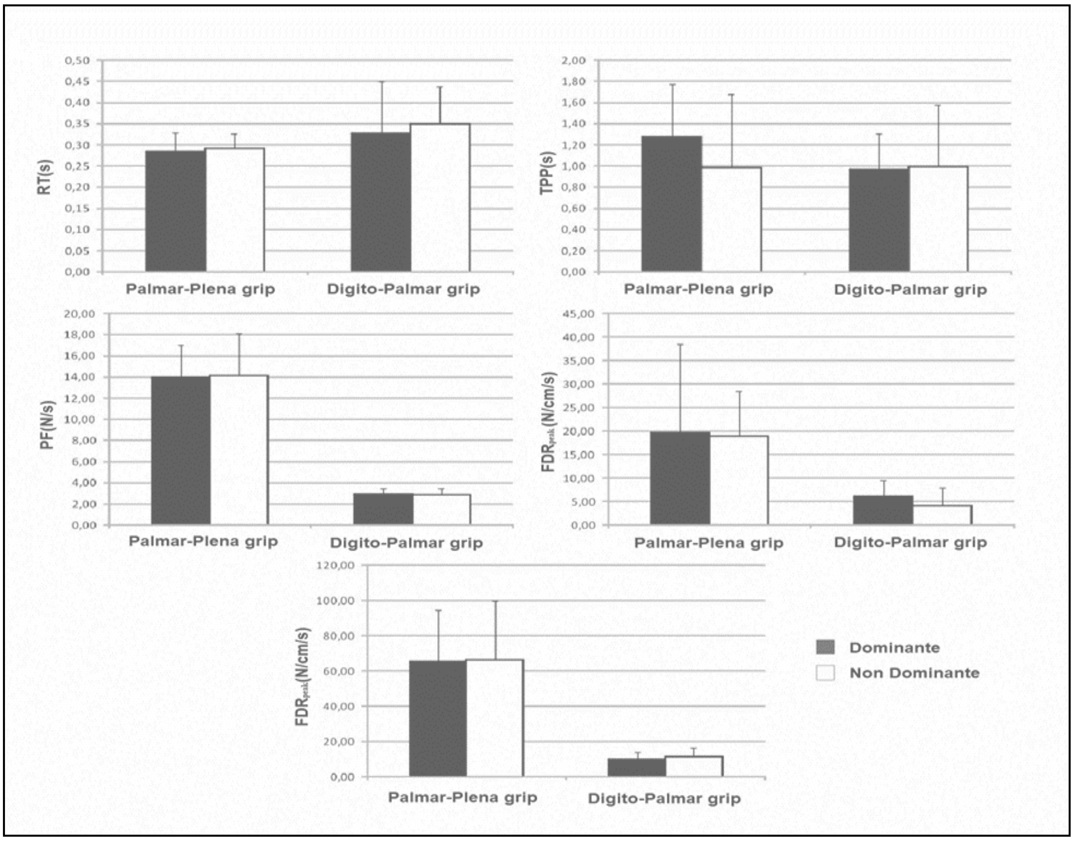

Figure 1. *Average force development rate from start to peak force (mean FDR), time to peak force development rate in 200ms (FDRpeak) and fall index (IQ) in the handgrip and lateral pinch grips (digito-palmar grip)*

For the comparisons between the dominant and non-dominant hand, no significant differences were found for reaction time, time from onset to peak force, peak force, mean force development rate in 200ms, peak development rate of force in 200 ms, mean of the rate of force development from onset to peak force, time to peak force development rate, and rate of fall in the hand grips and lateral pinch (Fig. 1). Additionally, a positive correlation was found between forearm circumference and peak strength in the dominant (r=0.750; p=0.02) and non-dominant (r=0.69; p=0.03) hands for the palmar grip; and enter the forearm circumference and peak force in both hands (dominant: r=0.86; p=0.004 and non-dominant: r=0.75; p=0.017) for gripping the pinch type.

Discussions

Aiming to investigate the characteristics of the grip in high-level judokas, it was found in this study that judokas use different forms of hand and finger disposition, depending on the location of the opposing judogi to be performed in the kumi-kata. It was verified that the athletes perform the kumi-kata in basically four different places in the opponent's judogi: 1) on the collars, using the full Palmar-Plena grip; 2) on the back, both above and below the opponent's arm, using the Digito-Palmar grip; 3) in the belt, both above and below the opponent's arm, also using the Digito-Palmar grip; and 4) in the sleeves grip, using the Association between Digit-Palmar and Lateral Pinch type grips (DPLPG). Several factors, such as the load, shape and function to be performed or used by the hands, can explain the use of different forms of handgrip on an object(Berguer et al., 1999; Hilty et al., 2011). Such specificity tends to optimize the interaction between the subject's hand and the object. Regarding the use of DPLPG type grips, although these are made up of more delicate and precise movements, in many situations digital grips are also used for the application of great forces. This occurs mainly in objects that are too small for the handgrip to be used or where there is space restriction, inadequate body posture or a peculiar orientation of the object to be manipulated (Mohammed et al., 2018; Sterkowicz et al., 2016). Thus, it appears that in high level judokas(Ache Dias et al., 2012; Beboucha, Belkadi, Benchehida, & Bengoua, 2021), the dominant hand is conditioned to predominantly perform the full Palmar-Plena and Dígito-Palmar grips and the non-dominant hand to perform DPLPG grips, with less use of the palm grips(Yahia, 2020). When comparing the parameters of the strength-time curve of the identified grip types, between the dominant and non-dominant hands, no differences were found between any of the studied parameters, which reveals the ability of high-level judo athletes to perform hand grip similarly with both hands. Regardless of your preferred laterality for each specific type of handle (La Monica et al., 2017). Additionally, this information can support the training of elite judokas, given that symmetrical levels of performance in handgrip between the dominant and non-dominant members are characteristic of this population(Ruiz-Ruiz et al., 2002). The data from the present study are in contradiction of the results of (Suchomel et al., 2016), who analysed non-athlete individuals (35-44 years), where it was observed that 36.9% of men presented differences greater than 10% between the dominant and non-dominant hand, in the values of maximum handgrip strength. (Bohannon et al., 2006) observed that in right-handed people the dominant hand tends to be stronger than the non-dominant with differences of up to 15.8%, while in people with sinister dominance this tendency is smaller and the difference reaches 12.1%. The main causes of these discrepancies may be due to differences between populations (elite athletes vs. non-athletes) and anthropometric characteristics of the individuals analysed in these studies (Detanico et al., 2012). Recently, it has been verified, when studying the peak handgrip strength in Judo, Jiu-jitsu, Rowing, Aikido and non-athletes that 30.9% of the Fmax variation is attributed to the dominance of the hands, 39.9% to the differences between the sports modalities and 21.3% to the interaction between the dominance of hands and group of individuals (Vertonghen, Theeboom, & Pieter, 2014). Regarding anthropometric characteristics, it has been observed that mean differences of 2 cm in the circumferences of the dominant and non-dominant forearms are enough to significantly influence the production of force between these limbs (Detanico et al., 2012). In the present study, the circumference of the forearm was correlated with the peak force obtained in each type of handgrip, and did not differ between the dominant and non-dominant limbs, which may partially explain the symmetry in the maximum force values between them.

However, the results found by most studies that specifically evaluated judo athletes corroborate the findings of this work. (Berguer et al., 1999) analysed the maximum handgrip strength in athletes from different sports, including professional judo athletes, and recorded values corresponding to 494.4 ± 48.9 N and 442.6 ± 95.1 N, for the dominant and non-dominant limbs, respectively. (Ache Dias et al., 2012; La Monica et al., 2017), when evaluating well-trained judokas, competitors at the national level, found values of 513.72 ± 81.58 N and 513.94 ± 78.94 N, for the maximum handgrip strength of dominant and non-dominant limbs, respectively. Both studies found no effect of limb dominance. In the present study, values between 449.32 and 455.52 N (14 to 14.1 N/cm, when normalized by the circumference of the forearm) were obtained for these parameters. RT and TPP are important variables for the ability to effectively respond to the opponent's offensive and defensive actions in a short period of time. It was found that the high-level athletes evaluated in this study presented values lower than those found in the literature for lower-level judokas, reaching values between 0.29 to 0.30 s and 1.23 to 1.28 s, for RT and TPP, respectively. (Hilty et al., 2011; Junior, Domenech, Dias, da Silva, & Junior, 2009; Keir et al., 1998; Kozin et al., 1999) found TPP values higher than those found in the present study (1.32 s to 1.88 s) in well-trained judokas, but at a lower level than the current sample, and in non-judoka individuals. In both cases, there was no limb dominance effect. When analyzing the parameters related to FDR and IQ, values between 61-63 N/cm/s were found for FDRpeak, 36-40 N/cm/s for FDRmean and 0.65-0.72 N/cm/s for IQ, in both analysed limbs. Such variables have been shown to be very important for carrying out explosive actions, such as, for example, to prevent the kumi-kata on the opponent's judogi from being undone (Benchehida et al., 2021; Blais, & Trilles, 2006)and for the maintenance of force production, have a view that the periods in which kumi-kata actions are performed can vary between 15 and 30 s during the fight (Miarka et al., 2012). In addition, such parameters allow characterizing the performance of the handgrip skill of judokas, as they are crucial for the success of the Judo kumi-kata (Stachoń et al., 2016). It is noteworthy that the values found in this study of FDR and IQ are higher and lower, respectively, than those obtained by other authors who evaluated well-trained judo players (Hilty et al., 2011; La Monica et al., 2017), which is determining the selectivity of the current sample. Additionally, it is worth highlighting some limitations of the present study.

Due to the scarcity of scientific studies involving the analysis of handgrip of the Lateral Pinch type in judokas, the discussion of this work was directed to the parameters related to the handgrip of the Palmar-Plena type, which is more frequently studied. However, the choice to analyse the handgrip of the Lateral Pinch type is justified because this is a complementary action to the DPLPG grips, which is more used by the non-dominant limb during combat, as verified in this study. Regarding the types of grip analysed, these were limited to the specificity of the task, allowing the assessment of only the grips of the palm and lateral pinch type, which was necessary to meet the ASHT recommendations and ensure better control of the experiment.

3. Conclusions

In high-level judokas, handgrip parameters did not differ between dominant and non-dominant limbs, which points to the importance of symmetry of these parameters in athletes who aspire to high-level judo. Furthermore, attention should be paid to specific training of different types of kumi-kata, since the use of this technique is dependent on limb dominance. This statement is justified by the different frequency of use of the types of handgrip found in this study, with those of the Palmar-Plena and Digit-Palmar types being more applied by the dominant limb, while those of the type "Association between Digit-Palmar and Pinch-Lateral" are more applied by the non-dominant member.

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