ORIGINAL ARTICLE

Correlation between roundhouse kick and countermovement jump performance

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: Taekwondo (TKD) is a combat sport in which leg techniques are predominant. Roundhouse (*bandal chagi*) is one of the kicking techniques commonly used in competition. Evaluate and monitoring the power and accuracy of each blow is crucial for training process. Sports scientists and coaches have used the countermovement jump to evaluate the strength and power of lower limbs muscles. However, it is not a specific taekwondo test. Therefore, it was interesting to compare kick and jump performance in order to show the importance of monitoring training by specifics tests. The purpose of this study was to correlate the countermovement jump performance with the roundhouse kick performance in TKD athletes. It was hypothesized that there will not be an elevated correlation between them.

Material & Methods: Thirty-one taekwondo athletes (18 males and 13 females), following familiarization procedures, performed three countermovement jumps and after about 10 minutes, three roundhouse kicks. Tests were performed in similar contact mats. There was an armoured inertial sensor inside a specific taekwondo racket.

Results: There was a strong, positive and significant correlation between tests for group ($r = 0.771$, $p<0.001$). The correlation to females was moderate ($r = 0.556$, $p<0.05$) and not significant to males ($r = 0.421$, $p = 0.082$). The r^2 value for group, females and males were 0.594, 0.309, and 0.177, respectively.

Conclusions: Once speed kick test is more specific, we suggest that it might be better to monitoring the athletes' performance by this test. The inertial sensor developed to this study is a simple and good way to monitoring the speed kick performance.

Key words: athletes • *bandal chagi* • combat sports • monitoring • specific test

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Athlete – *noun* **1.** someone who has the abilities necessary for participating in physical exercise, especially in competitive games and races **2.** a competitor in track or field events [25].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [25].

Taekwondo WTF – according with World Taekwondo Federation (WTF) taekwondo has been recognised as an Olympic sport since 2000. Taekwondo WTF, together with wrestling, judo, and boxing, is a combat sport that is a part of the Olympic Games programme. The changes occurring in refereeing rules of this competition influence its course [26].

Roundhouse or circular kick – a type of kick defined as throw-like kicks or progressive movements of hip and knee flexion-extension of the kicking leg that start in the sagittal plane and finish in the transverse plane (i.e., swing motion), with the ankle in plantar flexion to hit in lateral body posture with the instep.

Roundhouse kick – a type of kick executed to the chest that generally starts in the sagittal plane and finishes in the lateral

Introduction

Taekwondo (TKD) is a modern Olympic martial art [1] originally from Korea [2] whose competitors must be able to move with high power and speed [3]. Although athletes may use their fists and feet, kicking techniques are predominant in both, training and championships [4].

Band al chagi (roundhouse kick) is one of the most used kicking techniques and can be defined as a semi-circular kick performed with foot dorsum on the abdomen height of the opponent [5]. Falco et al. [6] in another words, described the roundhouse kick as a "multiplanar skill, which starts with the kicking leg travelling in an arc towards the front with the knee in a chambered position. The knee is extended in a snapping movement, striking the opponent with metatarsal part of the foot extended". The kick requires high precision and power of the lower limbs muscles [3]. Because of its high velocity and impact force, during a competition, the opponents have less time to react and more likely to concede points. Thus, the explosive turning kick is focused during TKD training [1].

Evaluate and monitoring the power and accuracy of each blow is crucial for training process, and as they are critical to the scoring system during competitions, they need to be well measured [7]. It`s possible to assess the athlete's performance in roundhouse kick technique through a kick speed test. It consists of carrying out the kick using a contact mat and a taekwondo racket connected to a computer program that measures the movement time [1].

The countermovement jump (CMJ) is a test widely used by sports scientists and coaches to evaluate the strength and power of lower limbs muscles in athletes from different sports [8], including TKD [5]. Studies verified the correlation between the CMJ and a specific capacity of different modalities. Kale et al. [9] found a significant and negative correlation between the CMJ and 100 m performance of sprinters (r = 0.46). Wisloff et al. [10] also found significant correlation between the CMJ height with the 10 m sprint time (r = 0.72), the 30 m sprint time (r=0.60) and the level of 1RM half squat (r = 0.78) in soccer players. Concerning the crucial importance of have volleyball-specific testing procedure, Sattler et al. [11] compared two volleyball-specific jumping tests, the block jump (BJ) and the attack jump (AJ) test, with two frequently used and systematically validated jumping tests, the CMJ and the squat jump (SJ) test. The correlation between tests were high, r = 0.75 to SJ and AJ, r = 0.89 to CMJ and BJ. Therefore, they conclude that volleyball-specific tests, which simulate real-game situations, should be used to test volleyball athletes for sport specific jumping abilities.

Although the muscle power of the lower limbs, estimated by vertical jumps, has been linked to competitive performance in TKD [4, 12], this is not a specific test to this modality and it may not be the best way to evaluate athletes performance in specifics tests, as explosive kicks. Therefore, it is interesting to compare kick and jump performance in order to show the importance of monitoring training by specifics tests. It was not found studies that compared jump and kick performance.

Thus, the aim of this study was to correlate the countermovement jump performance with the roundhouse kick performance in TKD athletes. It was hypothesized that there will not be a high correlation between them.

Material and methods

Subjects

This study included 31 individuals of both sexes (18 males and 13 females), TKD athletes in the UFMG Sports Training Centre, with mean age 20.17 ±1.89 years, mean body mass 63.82 ±9.22 kg and average height of 170.08 ±9.87 cm. All volunteers were aware of the procedures of the study and gave their consent for participation before undergoing the tests.

Procedures

Firstly, all participants had their body mass (kg) and height (cm) measured. After the initial procedures, each athlete first made the CMJ test. The technique used for vertical jump was the same as described by Menzel et al. [13]. The volunteers should keep its hands on the waist during all phases of the jump. Starting from orthostatic posture, the jump test consisted of a rapid eccentric action of knee flexion, hip flexion and feet dorsiflexion, to a position on which the volunteer consider to be the most efficient, followed by a rapid concentric action of the same segments extension, in order to activate the stretch-shortening cycle.

All volunteers should keep extended knees during the flight phase and landing should be in plantar flexion, so the first part to touch the mat should be the forefoot. They were also instructed to keep their head always facing forward. After received all this information, the participants performed about nine CMJ with the purpose of familiarization and warm up. Then, they performed three jumps with minimum interval of 30 s. The mean of the three jumps was used to statistical analysis.

Secondly, after a ten minutes interval, each athlete performed nine kicks to familiarize with the roundhouse kick speed test, followed by three kicks. The mean of the three kicks was used to statistical analysis. The kicking foot was kept standing on a contact mat. The volunteers were instructed to kick as fast as possible, with the preferred member, the taekwondo racket positioned at the height of the iliac crest of the individual, and the kick should be performed as soon as allowed. The mat used in the kick speed test was marked with the footage in centimetres between the mat position and the place where the racket was positioned.

A contact sensor was coupled into the racket for measuring the kick time, which corresponded to the contact loss of the kicking foot on the mat until the contact with the racket. The horizontal distance, defined by the length of the lower limbs plus the volunteer basis size, and the height of the iliac crest of the individual were used to calculate the hypotenuse, through the Pythagorean Theorem (Figure 1). The hypotenuse was considered as the distance between the initial position of the kicking foot and the racket. As this distance represents the displacement, it was used to calculate the kick speed through the equation:

$$KS = \sqrt{(HD^2 + HC^2)} / KT$$

Since KS is the kick speed, in m/s, HD the horizontal distance, in meters, HC the height of the iliac crest of the individual, in meters, and KT the kick time in seconds.

Instrumentation

Similar contact mats fixed to the ground were used, one for the CMJ test and other for the kick speed test. There were two computers connected to mats and contact sensor, using Multisprint Full program version 3.5.7 (Hidrofit Ltda. Brazil).

An armoured inertial sensor was placed inside a specific taekwondo racket. In the sensor interior there was a mass in form of spring that, in the moment that the feet made contact with the racket, an electric circuit get closed (Figure 2).

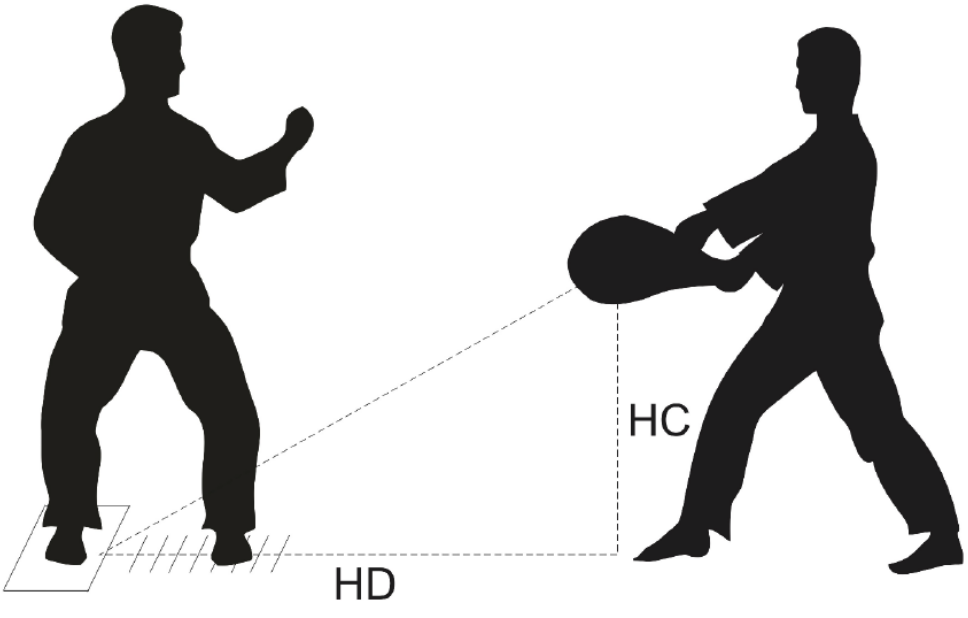

Figure 1. Roundhouse kick (model of the test and measurement criteria).

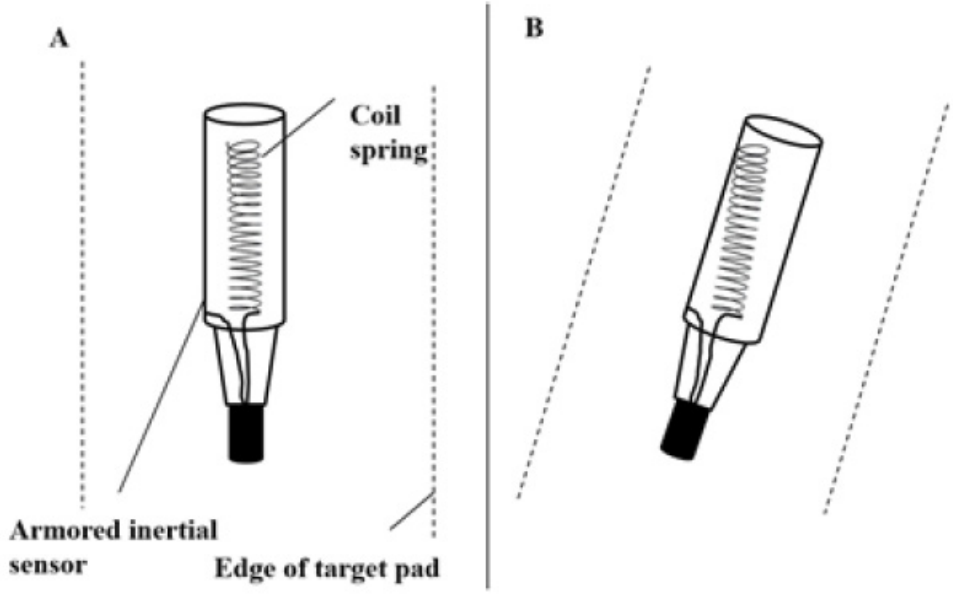

Figure 2. Coupled inertial sensor inside the target pad: (A) – before the kick contact; (B) – after the kick contact (closed electronic circuit between the coil spring and the armoured inertial sensor).

Statistical Analysis

Descriptive statistics of the data were analysed to group, and then separately to males and females. To verify the normality of the data the Shapiro-Wilk test was performed and to correlate them the parametric test of Pearson correlation was used, once data presented normal distribution. The significance level was 0.05. Statistical tests were performed on SPSS statistical package (version 20.0).

Results

Date is presented as mean, standard deviation, minimum and maximum values (Table 1). CMJ height and roundhouse kick speed data are shown for all volunteers and for each gender (female and male).

The Shapiro-Wilk test indicated a normal distribution for all the variables. The Pearson correlation indicated a strong, positive and significant correlation between tests for the group ($r = 0.771$, $p<0.001$) and a moderate, positive and significant correlation between tests for females ($r = 0.556$, $p<0.05$). The Pearson correlation did not indicate a significant correlation between tests for males ($r = 0.421$, $p = 0.082$). Figure 3 shows the correlation for group (Figure A), females (Figure B) and males (Figure C). The r^2 value for group, females and males were 0.594, 0.309 and 0.177, respectively.

Discussion

The main finding of this study was that although there was strong correlation between the roundhouse kick speed test and the performance on CMJ, the coefficient of determination (r^2) value was not high enough to indicate that one variable can predict other. It is important to note that the comparison was between a general test, commonly used in different sports, and a specific test, which can be useful for taekwondo coaches at a training program.

Considering the importance of training principle of specificity, studies have tried to verify the possibility of determining variables that characterize the physical conditions of the athletes through specifics tests. In this way, Mota et al., [14] tried to determine the intensity of the lactate threshold using the roundhouse kick. Sattler et al. [11] also investigated the correlation between specific tests, the block and attack jump in volleyball, with general tests, CMJ and SJ test. Similarly, the purpose of this study was to compare the performance of taekwondo athletes in two different tests. The CMJ test is frequently used and systematically validated [11] however, it does not represent a specific gesture in TKD.

Other studies had analysed kick speed in taekwondo athletes [1, 5] but it was not found any

Table 1. Descriptive statistics of variables

Test	Mean	Standard Deviation	Minimum Value	Maximum Value
All taekwondo athletes (n = 31)				
Countermovement jump (m)	**0.32**	± 0.08	0.18	0.45
Roundhouse kick speed (m/s)	**8.99**	± 0.92	6.42	10.46
Female (n = 13)				
Countermovement jump (m)	**0.24**	± 0.04	0.18	0.33
Roundhouse kick speed (m/s)	**8.24**	± 0.74	6.42	9.27
Male (n = 18)				
Countermovement jump (m)	**0.37**	± 0.05	0.31	0.45
Roundhouse kick speed (m/s)	**9.52**	± 0.61	8.17	10.46

study which performed the same experimental procedure of this study to verify the relationship between kick and jump performance. As far as we investigated, this was the first experiment to use the inertial contact sensor coupled in the racket. Jakubiak & Saunders [1] measured kicks with a digital timer and two pressure switches. Kick movement time, in the study of Moreira et al., [5], was considered as the elapsed time among the foot withdrawal from the ground and its return to the same place. However, it is important to highlight that the kick performance depends on a shorter time between the start of the kick and the foot contact with the opponent`s trunk. Therefore, the inertial sensor that was developed for this study is a simple and efficient way to monitor the kick speed performance.

About the coefficient of determination, when analysed separately, females and males, the r^2 value was only 0.309 and 0.177 respectively. Thus, only 30.9% of the variability in CMJ can explain the variability in roundhouse kick for females and only 17.7% of the variability in CMJ can explain the variability in roundhouse kick for males. Besides, the correlation for males was not significant. However, when both are analysed together, the group becomes more heterogeneous, and consequently more elevate correlations values are found. Even so, how the r^2 value for group (0.594) is yet small, the countermovement jump test (non-specific) is not good to replace the roundhouse kick test.

Although the CMJ is not considered a specific gesture from TKD, this study only investigated its correlation with the roundhouse kick. There are different kicking techniques in TKD as the

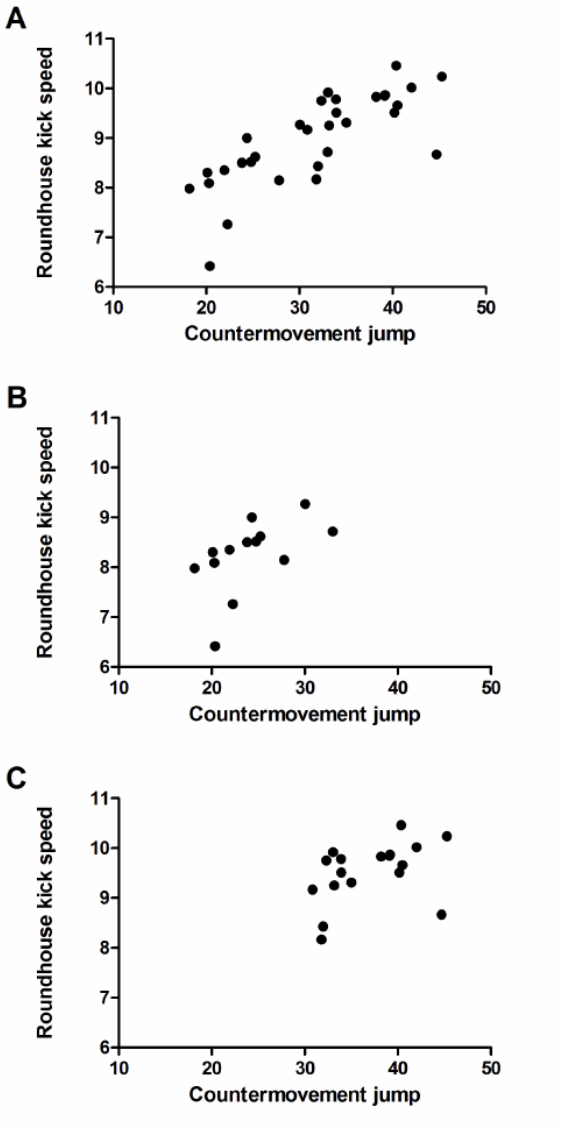

Figure 3. Correlation between *roundhouse* kick speed and countermovement jump for group (figure A), females (figure B) and males (figure C).

side kick, thrashing kick, and turning-back kick [2] and the CMJ performance may have a more elevate correlation and r^2 value between these and other specifics gestures of this modality.

Regardless of the criticism of the results of our researches from the perspective of suitability in sport, this kind and similar analysis [5, 15, 16] may be important for the application of taekwondo as a self-defence art when there is a need for acute means counterattacks [17-19]. Among the recommended testing of self-defence [19, 20] and military hand-to-hand fighting [21-23] the speed of impact with hands and legs is evaluated on the basis of expert observation. An interesting issue is to examine the compatibility of these expert assessments with the objective results of methodology used previously and in our researches on the test [15].

Regardless of the relations of taekwondo with self-defence each technique of taekwondo is applicable to *unifight* which is an authentic compilation of various combat sports and martial arts [24]. However every combat sports and martial arts is qualifying to self-defence art. However, this does not change the relationship that every combat sports is both a martial art but not vice versa [17].

Conclusions

In the present study was found strong, positive and significant correlation between CMJ performance and roundhouse kick speed. However, the r^2 value is not enough to indicate that the countermovement jump test (non-specific) can replace the roundhouse kick test. Once speed kick test is more specific, we suggest that it might be better to monitor the TKD athletes' performance by this test.

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References

1. Jakubiak N, Saunders DH. The feasibility and efficacy of elastic resistance training for improving the velocity of the Olympic taekwondo turning kick. J Strength Cond Res 2008; 22: 1194-1197
2. Kim YK, Kim YH, Shin JaIm. Inter-joint coordination in producing kicking velocity of Taekwondo kicks. J Sport Sci Med 2011; 10: 31-38
3. Kazemi M, Perri G, Soave D. A profile of 2008 Olympic Taekwondo competitors. J Can Chiropr Assoc 2010; 54: 243-249
4. Markovic G, Misigoj-Durakovic M, Trninic S. Fitness profile of elite Croatian female taekwondo athletes. Coll Antropol 2005; 29: 93–99
5. Moreira PVS, Crozara LF, Goethel MF et al. Talent detection in taekwondo: which factors are associated with the longitudinal competitive success? Arch Budo 2014; 1: 295-306
6. Falco C, Alvarez O, Castillo I et al. Influence of the distance in a roundhouse kick's execution time and impact force in Taekwondo. J Biomech 2009; 42: 242–248
7. Del Vecchio FB, Franchini E, Del Vecchio AHM et al. Energy absorbed by electronic +body protectors from kicks in a taekwondo competition. Biol Sport 2011; 28: 75-78
8. Laffaye G, Wagner P, Tombleson T. Countermovement jump height: gender and sport-specific differences in the force-time variables. J Strength Cond Res 2014; 28: 1096-1105
9. Kale M, Asci A, Bayrak C et al. Relationships among jumping performances and sprinters parameters during maximum speed phase in sprinters. J Strength Cond Res 2009; 23: 2272-2279
10. Wisloff U, Castagna C, Helgerud J et al. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. Br J Sports Med 2004; 38: 285–288
11. Sattler T, Sekulic D, Hadzic V et al. Vertical jumping tests in volleyball: Reliability, validity, and playing-position specifics J Strength Cond Res 2012; 26: 1532–1538
12. Teyl WJ, Kwong VKW, Rassiah D et al. Physiological characteristics of Malaysian national elite and subelite taekwondo athletes. Braz J Sports Med 2010; 44: 1-7
13. Menzel HJ, Chagas MH, Szmuchrowski LA et al. Usefulness of the jump-and-reach test in assessment of vertical jump performance. Percept Motor Skill 2010; 110: 150-158
14. Mota GR, Magalhães CG, Azevedo PHSM et al. Lactate Threshold in Taekwondo through Specifics Tests. J Exerc Physiol Online 2011; 14: 60-66
15. Oliveira MA, Szmuchrowski LA, Gomes Flor CA et al. Correlation between the performance of taekwondo athletes in an Adapted Anaerobic Kick Test and Wingate Anaerobic Test. In: Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 130–134
16. Wąsik J, Czarny W, Małolepszy E et al. Kinematics of taekwon-do front kick. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 23-29
17. Kalina RM. Teoria sportów walki. COS: Warszawa; 2000 [in Polish]
18. Harasymowicz J, Kalina RM. Training of psychomotor adaptation – a key factor in teaching self-defence. Arch Budo 2005; 1(1): 19-26
19. Harasymowicz J, Kalina RM. Honourable self-defence – the theoretical and methodological basis of training. Płock: Wydawnictwo Novum; 2006
20. Kalina RM, Jagiełło W, Wiktorek P. Motor competence in self-defence of students of a detectives' school during their course of studies. Arch Budo 2007; 3(3): 1-6
21. Carzyński M, Kalina RM, Kałużny R et al. Próba wstępnego zweryfikowania trafności testów służących ocenie wytrenowania żołnierzy w zakresie walki wręcz. In: Litwiniuk S, Bujak Z, Litwiniuk A, editors. Optymalizacja struktury treningu i współzawodnictwa w sportach walki. Biała Podlaska; 2000: 23-31 [in Polish]
22. Ashkinazi S, Jagiełło W, Kalina RM et al. The importance of hand-to-hand fights for determining psychomotor competence of antiterrorists. Arch Budo 2005; 1(1): 8-12
23. Ashkinazi S. The experience of the scientific basing of the time resources for military service

men training in hand-to-hand fighting. Arch Budo 2007; 3(3): 35-41

24. Harasymowicz J, Novikov S. Axiological, ethical and utilitarian benefits of UNIFIGHT. Arch Budo 2013; 9(4): 227-232

25. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006

26. Śledziewski D, Łoniewski M, Kuder A et al. Fighting profiles in men's taekwondo competition in the under 68 kg category at the Olympic Games in Beijing (2008) and London (2012) – case studies. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 1-9

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