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Evaluation of the functional state of taekwondo athletes 7-13 years old according to the indicators of the finger-tapping test

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Abstract

Background and Study Aim. The functional state of organs and systems determines the level of preparedness of athletes in modern sports. The evaluation of the state of the central nervous system is of particular importance. The purpose of the study is a comparative analysis of the results of the tapping test of taekwondo athletes of different ages.

Material and Methods. 42 taekwondo athletes were divided into groups of 14 people depending on age: group 1 - (7.50±0.14) years, group 2 - (10.07±0.22) years, group 3 - (13.36±0.27) years. Participants of groups 1 and 2 were engaged in the amateur level, and group 3 had a skill level of 2 Gup - 1 Dan. A special computer program for devices with the iOS operating system was used. An Apple tablet was used - iPad, 4th generation with a screen diagonal of 9.7 inches. The finger-tapping test was carried out for 60 s, 12 subtests of 5 s each. For analysis, we evaluated the total number of depressions during the entire test, the average number of depressions per 5 s, the number of depressions in each subtest, the duration of depressions in each subtest, and the dynamic performance index (DPI). Group results were compared using the nonparametric Rosenbaum test (Q) and sign test (z).

Results. It was found that the athletes of the 2nd group performed more depressions in the test as a whole and in 11 out of 12 subtests compared with the athletes of the 1st group. Comparison of the middle and senior groups also confirmed the best results of the athletes of the senior group in 6 subtests out of 12. The senior athletes had a longer duration of depressions in 2 subtests. The most pronounced differences were established when comparing the results of the junior and senior groups. A significant excess in the number of depressions was confirmed for senior athletes in all subtests. The duration of depressing was longer in senior athletes in 2 subtests. A significant reduction in the number of depressions from the beginning to the end of the test was determined. Changes in the duration of depressions were opposite, and the time increased from the beginning to the end of the test.

Conclusions. The presence of a direct dependence of the results of the finger-tapping test of taekwondo athletes on age is determined. An increase in the number of depressions in the test, an increase in the integral criterion - an indicator of dynamic performance was determined. The results reflect an increase in the strength of nervous processes, positive changes in the functional state under the influence of regular training loads. This condition should be evaluated as a predictor of the success of taekwondo athletes. The computer version of the test is mobile, informative and valid. It can be used in monitoring the functional state of combat sports athletes.

Keywords: combat sports, taekwondo, finger tapping test, age groups.

Анотація

Ольга Подрігало, Вячеслав Романенко, Леонід Подрігало, Сергій Єрмаков, Олег Ольховий, Анастасія Бондар, Алла Семізорова, Володимир Галімський. Оцінка функціонального стану таеквондістів 7-13 років за показниками теппінг-тесту. Мета: порівняльний аналіз результатів тепінг-тесту атлетів таеквондо різного віку. **Матеріали і методи**: 42 атлети таеквондо були поділені на групи по 14 осіб залежно від віку: 1 група – середній вік (7.50±0.14) років, 2 група – (10.07±0.22) року,

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3 група – (13.36±0.27) років. Учасники 1 та 2 груп займалися на аматорському рівні, 3 група мала рівень майстерності 2 Gup – 1 Dan. Використовували спеціальну комп'ютерну програму для пристроїв з операційною системою iOS. Було використано планшетний комп'ютер фірми Apple – iPad, 4-го покоління з діагоналлю екрану 9,7 дюймів. Тепінг-тест проводився протягом 60 секунд, 12 субтестів по 5 секунд. Для аналізу використовували загальну кількість натискань протягом усього тесту, середню кількість натискань за 5 с, кількість натискань у кожному субтесті, тривалість натискань у кожному субтесті, показник динамічної працездатності (ПДР). Результати груп порівнювали за допомогою непараметричного критерію Розенбауму (Q) та критерію знаків (z). **Результати:** аналіз результатів 1 і 2 групи показує, що старші атлети виконували більшу кількість натискань у тесті в цілому та в 11 субтестах із 12. Порівняння середньої та старшої груп також підтвердило кращі результати атлетів старшої групи за 6 субтестами з 12. Старші атлети мали більше натискань під час виконання 2 субтестів. Найбільш виражені відмінності встановлені при порівнянні результатів молодшої та старшої груп. Підтверджено значне перевищення кількості натискань у старших атлетів за усіма субтестами. Тривалість натискань була більшою у старших атлетів за двома субтестами. Аналіз динаміки виконання тесту показав значне скорочення кількості натискань від початку до кінця тесту. Зміни тривалості натискань були протилежні, час збільшувався з початку до кінця тесту. **Висновки:** показано наявність прямої залежності результатів тепінг-тесту атлетів таеквондо від віку. Встановлено збільшення кількості натискань у тесті, зростання інтегрального критерію – показника динамічної працездатності. Результати відбивають збільшення сили нервових процесів, позитивні зміни функціонального стану під впливом регулярних тренувальних навантажень. Комп'ютерний варіант тесту є мобільним, інформативним та валідним. Він може бути використаний у моніторингу функціонального стану атлетів єдиноборств.

Ключові слова: єдиоборства, таеквондо, теппінг-тест, вікові групи

Introduction

The functional state of organs and systems determines the level of preparedness of athletes in modern sports. The assessment of the state of the central nervous system is of particular importance. Many sports place high demands on the nervous system and, especially, on the ability to function in extreme conditions (Svitlana et al., 2020). Athletes of extreme sports are characterized by high indicators of the strength of nervous processes, reactions to a moving object, and an increase in the level of dynamic muscle endurance under the conditions of a finger tapping test. These psychophysiological features may have prognostic value.

Motor speed is an important indicator and predictor of cognitive and physical function. One of the most common methods for assessing the speed of movements is the finger tapping test (FTT) (Austin et al., 2011). This test belongs to the classical methods of analyzing the psychophysiological state of a person (Austin et al., 2011; Mochurad & Hladun, 2021), analyzing performance, diagnosing, and predicting fatigue (Prigatano et al., 2020), assessing the speed of motor skills and motor control (Christianson & Leathem, 2004), and measuring the motor activity of the upper limbs (Barut et al., 2013).

FTT assesses fine motor skills, the ability to control and coordinate precise movements with the muscles of the hand. Fine motor skills are associated with information processing speed functions, learning skills, and other cognitive abilities. In a study by Sahin et al. (2020) carried out a comparative analysis of the results of FTT in elite athletes and students of various specialties. The test results were used as a criterion for the effectiveness of training. Similar results were obtained in another study (Ari & Deliceoglu, 2020). The results of the finger tapping test made it possible to assess the level of maturation of primary schoolchildren. The informativeness of this test for assessing the development of motor skills has been confirmed.

Correlation between motor qualities, physical fitness, and academic performance of schoolchildren was determined using FTT (Batez et al., 2021). It is confirmed that test results are significant predictors of academic performance. Their contribution to the GPA was the largest.

An important task of sports science is the choice of adequate and informative tests to monitor the condition of athletes and amateurs (Butenko et al., 2017). The reliability and informativeness of FTT served as the basis for its use in assessing the physical fitness of students (Duc, 2021). The conclusion is made about the possibility of using this test in health monitoring.

FTT is used to analyze the state of the nervous system of athletes and assess the potential of functionality and effectiveness of training (Balgimbekov et al., 2021; Bisio et al., 2021; Ambroży et al., 2022). It allows to evaluate the ability to synchronize movements. This quality also applies to predictors of success in many sports. A comparative analysis of the results of the finger tapping test in tennis athletes and the control group was carried out in another study (Bisio et al., 2021). The best level of development of motor skills in athletes, higher quantitative and qualitative indicators of test performance are determined.

A comprehensive analysis of the anthropometric profile and fitness profiles of junior karate athletes was conducted in the study (Martinez-De-Quel et al., 2021). The finger tapping test was part of the used test battery. The results confirm the high level of preparedness of the athletes. Participants were between the 80th and 90th percentile compared with the general population.

Similar results were obtained in another study (Ambroży et al., 2022). The authors studied the effectiveness of using a fitness program in the training of kickboxing athletes. Significant changes in the indicators of general and special physical training were determined. A significant optimization of the results of the findertapping test was confirmed in the dynamics of the state of the participants.

The psychomotor characteristics of elite athletes were studied in another study (Petrenko et al., 2021). High rates of mobility of nervous functions and finger tapping test were determined in middle-distance runners. It is proposed to use psychomotor indicators for the selection and specialization of athletes in athletics at each stage of training. These indicators can be used to predict individual progress and correct general and special physical fitness.

The conditions of the test must be appropriate for the activity to be performed. This created a foot version of the test. The foot tapping test (TAP) is also widely used in sports science. Its reliability, validity, and sensitivity in football players have been confirmed (Chaabouni et al., 2022). A high correlation of TAP and FTT results was determined. The conclusion is made about the prospects of its use in sports where the main load falls on the lower limbs.

Both options (TAP and FTT) were used to analyze the state of female athletes in artistic and rhythmic gymnastics in the dynamics of training (Scotton et al., 2021). The effect of two opposite factors associated with training load has been confirmed. The development of fatigue minimizes productivity. The formation of neuromuscular activation is aimed at improving performance.

Similar results are presented in another study (Aksović et al., 2021). The authors investigated the impact of the development of motor skills on the results in the sprint. TAP and FTT results had a significant impact on performance. The correlation with speed and explosive power was confirmed.

Thus, the available results confirm the relevance of using the finger tapping test for the selection and prediction of the growth of sportsmanship, monitoring the condition of athletes. It is of interest to evaluate its features in combat sports athletes of various age groups.

Based on the foregoing, the **aim of this study** was a comparative analysis of the results of the finger tapping test of taekwondo athletes of different ages.

Material and Methods of the research

Participants.

The study involved 42 taekwondo athletes and representatives of the Vulkan sports school (Cherkasy, Ukraine). The participants were divided into groups of 14 people depending on age: group 1 - (7.50±0.14) years, group 2 - (10.07±0.22) years, group 3 - (13.36±0.27) years. Participants of groups 1 and 2 were engaged in the amateur level, and group 3 had a skill level of 2 Gup - 1 Dan.

Ethics Statements and Participants. This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki. All participants and his parents gave their written consent to research and were informed about the purpose and test procedures and about the possibility of withdrawal of consent at any time for any reason.

Study design.

The design of the study involved conducting a finger tapping test by depressing on the screen. The duration of the test was 60 s. Participants sequentially performed 12 subtests for 5 s in separate squares of the screen. A special computer program for devices with the iOS operating system was used. The device used was an Apple tablet computer - iPad, 4th generation with a screen diagonal of 9.7 inches.

For analysis, we used the total number of depressions during the entire test (abs), the average number of depressions per 5 s (abs), the number of depressions in each subtest (abs), and the duration of depressions in each subtest (ms).

The dynamic performance index (DPI) was determined as an integral criterion for the strength of nervous processes (Makarenko, 1996). This criterion was found by the formula:

$$DPI = -0.06 \times (-6 \times n_1 - 5 \times n_2 - 4 \times n_3 - 3 \times n_4 - 2 \times n_5 - n_6 + n_7 + 2 \times n_8 + 3 \times n_9 + 4 \times n_{10} + 5 \times n_1 + 6 \times n_{12}) \quad (1),$$

where n is the number of depressions in a particular subtest.

Statistical analysis of the obtained data was carried out using licensed MS Excel. The indicators of descriptive statistics were determined: arithmetic mean (X) and standard deviation (SD). Considering the size of the sample and the nature of the data distribution, the significance of differences between the groups was assessed using a nonparametric indicator - the Rosenbaum test (Q), the differences were considered significant at ($p<0.05$). The dynamics of the test results within the groups were assessed by comparing 1, 7, and 12 subtests using the sign test (z), and differences were considered significant at ($p<0.05$).

Results of the research

The results obtained are shown in table 1.

Table 1. Results of the finger tapping test for taekwondo athletes of different age groups (X±SD)

Indicator	1 group (n=14)	2 group (n=14)	3 group (n=14)
Total number of depressions, abs	300.50±19.08	345.29±22.38	374.50±70.32
Average number of depressions per 5 s, abs	25.06±1.59	28.79±1.87	31.18±5.87
Number of depressions in subtest 1, abs,	30.21±2.01	33.86±2.60	35.29±8.52
Number of depressions in subtest 2, abs	28.00±2.08	31.43±2.28	34.14±9.75
Number of depressions in subtest 3, abs	26.71±2.13	30.57±2.31	33.29±9.90
Number of depressions in subtest 4, abs	25.64±1.50	28.93±2.59	31.86±6.80
Number of depressions in subtest 5, abs	24.71±2.64	28.57±2.21	31.36±6.81
Number of depressions in subtest 6, abs	24.36±2.06	28.00±2.72	29.36±2.87
Number of depressions in subtest 7, abs	24.00±1.88	27.21±2.72	30.29±6.81
Number of depressions in subtest 8, abs	23.57±2.31	26.36±3.46	27.79±2.99
Number of depressions in subtest 9, abs	23.29±1.77	27.29±2.13	30.36±7.70
Number of depressions in subtest 10, abs	24.07±2.46	27.43±1.91	28.71±3.10
Number of depressions in subtest 11, abs	23.07±2.13	27.57±2.68	29.50±7.23
Number of depressions in subtest 12, abs	23.07±3.02	27.71±3.63	28.86±3.18
Duration of depressions in subtest 1, ms	62.75±11.79	65.53±12.18	73.44±18.98
Duration of depressions in subtest 2, ms	66.73±13.32	69.24±11.27	76.10±15.04
Duration of depressions in subtest 3, ms	69.51±20.21	72.63±16.46	75.88±16.52
Duration of depressions in subtest 4, ms	67.89±17.62	72.16±17.45	74.49±18.75
Duration of depressions in subtest 5, ms	72.86±18.17	68.67±11.69	72.36±17.68
Duration of depressions in subtest 6, ms	75.21±22.29	67.19±10.68	72.36±16.33
Duration of depressions in subtest 7, ms	70.70±20.31	70.12±13.43	75.54±17.89
Duration of depressions in subtest 8, ms	74.75±21.87	71.21±16.92	78.25±20.64
Duration of depressions in subtest 9, ms	76.46±20.13	71.00±14.41	73.08±15.62
Duration of depressions in subtest 10, ms	69.84±14.99	68.58±12.59	80.80±16.07
Duration of depressions in subtest 11, ms	75.97±14.63	70.14±13.59	80.66±15.25
Duration of depressions in subtest 12, ms	78.03±20.54	67.66±16.41	80.74±14.66
Dynamic performance index, abs	5.27±1.34	4.73±2.02	5.45±5.32

The analysis made it possible to determine many significant differences between the groups. The main trend was an increase in test results in direct proportion to age. When comparing groups 1 and 2, a significant increase in the total number of depressions (Q=21, p<0.01), the average number of depressions per 5 seconds (Q=21, p<0.01), the number of depressions in subtests 1–12 (p<0.01) were confirmed.

When comparing groups 2 and 3, a significant increase in the total number of depressions (Q=7, p<0.05), the average number of depressions per 5 seconds (Q=7, p<0.05), the number of depressions in subtests 4.5,6,7.9, 10 (p<0.05). In group 3, an increase in the duration of depressions was found in subtest 6 (Q=8, p<0.05), in subtest 10 (Q=11, p<0.01). DPI was higher in group 3 (Q=25, p<0.01).

The differences between groups 1 and 3 were the most pronounced. A significant increase in the total number of depressions (Q=23, p<0.01), the average number of depressions per 5 seconds (Q=23, p<0.01), the number of depressions in subtests 1–12 (p<0.05) were confirmed. Senior athletes had a longer duration of depressions in subtest 1 (Q=8, p<0.05), in subtest 10 (Q=7, p<0.05). DPI was higher in group 3 (Q=26, p<0.01).

In group 1, a significant decrease in the number of depressions between subtests 1 and 7 (z=0, p<0.01), subtests 1 and 12 (z=0, p<0.01), an increase in the duration of depressions between subtests 1 and 7 (z=3 , p<0.05), an increase in the duration of depressions between subtests 1 and 12 (z=1, p<0.01). In group 2, a significant decrease in the number of depressions was confirmed between subtests 1 and 7 (z=0, p<0.01), subtests 1 and 12, (z=1, p<0.01). In group 3, a significant decrease in the number of depressions between 1 and 7 subtests (z=0, p<0.01), 1 and 12 subtests (z=0, p<0.01), an increase in the duration of depressions between 1 and 12 subtests (z=3 , p<0.05).

Discussion

Combat sports are very popular sports among young people (Bayraktar et al., 2021; Lyuchkova et al., 2022). This necessitates the development of methods for selecting and predicting the effectiveness of training athletes. The most informative in this context is the study of physical development and functional state (Podrigalo et al., 2019; Romanenko et al., 2020).

The choice of the finger tapping test to assess the psychophysiological state of the participants was due to its availability, integrity and validity. This test is widely used in sports science (Duc, 2021; Balgimbekov et al., 2021; Bisio et al., 2021; Petrenko et al., 2021), including combat sports (Ambroży et al., 2022; Martinez-De-Quel et al., 2021; Korobeynikov et al., 2020).

Features of the complex visual-motor reaction of boxers with different types of functional asymmetry were assessed using the time of simple and two complex visual-motor reactions (Korobeynikov et al., 2020; Korobeynikov et al., 2019). The motor component of the motor response was studied using the finger tapping test. The results are interpreted as a reflection of the predictors of the success of athletes.

Variations of FTT are widely used in scientific research. It has been proposed to use a short version of this test to check the neuropsychological status of participants (Ashendorf et al., 2015). It was confirmed that both versions of the test have a high predictive and informative value.

The development of multimedia technologies has made it possible to develop computer and mobile versions of FTT (Mochurad & Hladun, 2021; Christianson & Leathem, 2004; Behrens et al., 2022). A special application for a cell phone has been developed that allows performing the FTT (Mochurad & Hladun, 2021). This application is characterized by information content, allows conducting research quickly directly in the process of activities.

The CoGNIT tablet application was developed for automatic, standardized and efficient assessment of cognitive functions (Behrens et al., 2022). The possibility of automatic testing using the specified application for assessing memory, psychomotor speed, executive function, attention, visual-spatial abilities was confirmed. A comparative analysis of the computer version of the test with traditional similar methods was carried out in another study (Christianson & Leathem, 2004). A high correlation between the results of the methods used was confirmed.

In our study, a program based on an Apple iPad, was used. The use of such programs allows you to quickly monitor the functional state of athletes, adjust training loads (Romanenko et al., 2020; Podrigalo et al., 2023).

A broad system of indicators was used to evaluate the test results. It included the number of total and average depressions, the number of depressions in each subtest, the duration of depressions in each subtest, as well as the integral indicator - DPI. This makes it possible to significantly improve the quality of the analysis of the results.

Similar approaches are described in the available literature. Austin D, Jimison H (2011) suggested using not only the number of depressions, but also the duration of the intervals between depressions to evaluate FTT. The presence of significant dependencies between the average speed of depressions and the average value of such intervals has been determined. A similar system of criteria was used in another study (Bisio et al., 2021). It included the frequency of movements, the duration of depressions, the duration of the interval between depressions.

The validity of the choice of indicators for evaluating the test results is confirmed by the available literature data. The average number of depressions and the temporal fluctuations of the intervals between depressions were used in another study (Barut et al., 2013). The use of these indicators significantly increases the level of results analysis.

The design variant used is the comparison of athletes of different age groups is widely used in sports science. This approach allows us to evaluate the influence of age, the increase in the length of training on the level of preparedness of athletes. In another study (Martinez-De-Quel et al., 2021), such an analysis made it possible to determine reference values for the parameters of combat sports athletes. It is recommended to use them when testing young male and female karate athletes.

Comparison of artistic swimming athletes of different skill levels was carried out in another study (Rovnaya et al., 2016). Experienced athletes were characterized by higher functional capabilities of the respiratory system. A direct relationship has been established between the experience of training and the adaptive potential of female athletes.

Comparison of the psychophysiological state of athletes of different skill levels was carried out in another study (Romanenko et al., 2020). It was confirmed that more experienced athletes completed the tests faster, with fewer errors. Parallel monitoring of physiological parameters confirmed the absence of adaptation stress. Experienced athletes have the best level of workability, the best ability to mobilize and economize the work of the body. Our results confirm the data presented in this study.

Performing an FTT is a complex task, the results of which

are influenced by many factors. These include external stimuli, mood and health status. In a sports context, it is also necessary to consider the level of skill, physical and technical training of athletes.

The ability to perform movements with maximum frequency is an integral indicator of speed (Makarenko, 1996). It is the nervous system that determines the speed qualities of athletes, due to its mobility, lability and endurance. The strength of nervous processes is an indicator of the performance of nerve cells and the nervous system as a whole. A strong nervous system withstands a load greater in magnitude and duration than a weak one (Makarenko, 1996). Therefore, the use of FTT makes it possible to predict the success of athletes in combat sports. A comparison of the results of athletes of different ages makes it possible to evaluate the effectiveness of their training, to predict the growth of sportsmanship (Podrigalo et al., 2023).

A direct dependence of test results on age has been confirmed. The senior athletes performed more presses on the test than the junior athletes. The DPI also increased with age. This relationship was confirmed when comparing all groups. Thus, the ability to maintain the maximum rate of hand movement increases with age. This is due to an increase in the strength and endurance of the nervous system.

An improvement in the psychophysiological parameters of combat sports athletes in parallel with age and training experience was researched in another study (Podrigalo et al., 2023). A positive change in the speed of reaction to various stimuli of taekwondo athletes of different ages was confirmed. The determined correlations between all tests used also reflect the improvement in the psychophysiological state of the athletes as the age increases.

The total number of depressions in the test characterizes the dynamic muscle performance. It was high enough in all groups. The increase in this indicator with age illustrates the increase in fitness, optimization of the functional state of athletes under the influence of regular physical activity. The results of FTT confirm the increase in the strength of nervous processes, overall performance due to sports training. Positive changes in the nervous system with age arise due to the high motor density of training, the use of high-intensity speed-strength and self-strength loads in training (Latyshev et al., 2022).

Analysis of the results of groups 1 and 2 shows that senior athletes performed more depressions in the test as a whole and in 11 out of 12 subtests. This allows concluding that the functional state of the nervous system of senior athletes is better.

Comparison of the middle and senior groups also confirmed the differences in the results of the finger tapping test. However, they were less pronounced than when comparing the junior and middle groups. The best results of the athletes of the senior group were determined in 6 out of 12 subtests. The senior athletes had a longer duration of depressions when performing 2 subtests.

The most pronounced differences were determined when comparing the results of the junior and senior groups. A significant excess in the number of depressions was confirmed for senior athletes in all subtests. The senior athletes had a longer duration of depressions when performing 2 subtests.

The results of FTT depending on gender, age and performance level were researched in the study by Prigatano et al. (2020). A direct correlation between age and the number of depressions has been determined. Females had more errors than males. The effects of fatigue and learning did not depend on the gender and age of the participants.

Similar results were obtained in another study (Christianson & Leathem, 2004). The higher performance of males compared to females, better results of the dominant hand and a decrease in the number of depressionsin the dynamics of the test were confirmed.

An analysis of the dynamics of the test execution made it possible to determine a significant reduction in the number of depressions from the beginning to the end of the test. Changes in the duration of depressions were opposite, the time increased from the beginning to the end of the test. However, this dependence was determined only in the junior and senior groups.

The results obtained confirm the available literature data. Higher FTT results in elite athletes have been determined in another study (Sahin et al., 2020). It is concluded that this test can be used as a predictor of success in sports.

An analysis of the motor abilities of preschool children, primary school and secondary school age involved in football was carried out in another study (Bubnjević et al., 2020). The correlation between test results has been confirmed to increase as the age of the participants' increases. Our results confirm a pronounced improvement in FTT results with increasing age and increasing experience in sports among junior taekwondo athletes.

Conclusions

Analysis of the results of the finger tapping test of taekwondo athletes of different ages showed direct dependence on age. An increase in the number of depressions in the test, an increase in the integral criterion - a dynamic performance index was determined. The results reflect an increase in the strength of nervous processes, positive changes in the functional state under the influence of regular training loads. This condition should be evaluated as a predictor of the success in taekwondo athletes. The computer version of the test is mobile, informative and valid. It can be used in monitoring the functional state of combat sports athletes.

Author Contributions

Olha Podrihalo: study design, data collection, statistical analysis, manuscript preparation.

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Conflicts of Interest

The authors declare no conflict of interest.

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