

Methodology for evaluating the “Go/No-Go” reaction in martial arts

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Abstract:

The complex sensorimotor response known as "Go/No-Go" is a critical component in combat sports. The mental composure of athletes considerably impacts the effectiveness and efficiency of their technical and tactical actions, ultimately influencing their competitive success. This study aimed to develop a method for evaluating the "Go/No-Go" reaction in martial artists through the use of computer technologies. The research involved 41 Taekwondo ITF athletes, with an average age of 16.5 ± 2.78 years, ranging in qualification from 4 Gup to 1 Dan. In the first phase, a preliminary test of the “Go/No-Go Reaction” mobile application was performed with 25 Taekwondo athletes whose average age was 15.4 ± 1.69 years. Software modeling and testing were used to detect potential errors and establish procedural configurations. In the second stage, 16 taekwondo athletes with an average age of 17.6 ± 3.87 years participated to determine the reliability, validity, and accuracy of the developed method. The study developed a method for evaluating “Go/No-Go” reaction levels in martial artists using modern technologies, including mobile devices running iOS and iPadOS. Testing different settings in the app revealed specific features of test performance. For example, a stimulus interval of "1-3 s" proved to be more efficient due to shorter test durations, which is beneficial in group testing. However, a longer interval of "2-4 s" was more similar to round lengths in most striking combat sports, making it suitable for testing elite athletes.

Key Words: computer technologies, mobile application, sensorimotor reaction, Go/No-Go, martial arts, combat athletes.

Introduction.

The success of competitive performance in martial arts directly depends on the athletes' reaction speed under conditions of increased physical activity and dynamic situational variability. Performance outcomes are determined by the degree of mastery of technical techniques and the level of tactical preparation. The adequacy of psychophysiological responses to training or competitive loads serves as an indicator of an athlete's level of preparedness and reflects the degree of fatigue and overstrain processes. The development level of complex sensorimotor reactions is a critical practical parameter for athletes (Strelchuk et al., 2022). A high degree of these reactions facilitates the rapid acquisition of technical and tactical skills and ensures the effective resolution of tasks during a competitive bout.

Training and competitive activities in martial arts contribute to the formation of a set of specific reactions and perceptual abilities in athletes, which are based on the thresholds of sensitivity of various sensory systems. In this process, the leading role is played by the development levels of motor, visual, vestibular, and auditory perceptions (Tropin et al., 2022). As the level of athletic mastery increases, the significance of developing psychophysiological functions becomes more critical for achieving high competitive performance (Dakal, 2015).

The growing level of competition and the specificity of modern competitive disciplines in martial arts necessitate the improvement of methods for assessing and developing sensorimotor reactions. Success in martial arts disciplines such as ITF Taekwondo, WTF Taekwondo, Karate, Kickboxing, and others largely depends on athletes' ability to quickly and accurately respond to their opponents' actions (Tropin et al., 2024). This is particularly important in the context of high psychological stress accompanying every competitive bout.

The significant demands for speed and accuracy in executing technical and tactical actions, as well as the need to distinguish between genuine and deceptive opponent actions, impose complex cognitive-motor challenges on athletes (Albuquerque, 2021). Under such conditions, there arises a necessity to enhance sensorimotor interaction mechanisms, enabling quick situational assessment, decision-making, and precise motor responses. In modern martial arts technical and tactical actions under high psychological pressure are crucial. Success in combat depends on athletes' ability to react quickly and efficiently to opponents, particularly in fast and intense confrontations. The balance of excitation and inhibition processes is essential for choosing

appropriate tactical responses. Psychophysiological characteristics provide valuable information for training optimization (Korobeinikova et al., 2024). The "Go/No-Go" reaction assessment helps measure athletes' self-control and attention, which is important for improving training efficiency and enhancing performance. Developing reliable and validated tests for assessing reaction types is a key task for sports scientists (Tropin et al., 2024). This study aims to improve the evaluation of sensorimotor reactions to boost the training process and athletes' preparedness.

A feature of sports activities in martial arts (taekwon-do ITF, taekwondo PTF, karate, kickboxing and others) is the performance of various technical and tactical actions against the background of high mental tension. In such conditions, the success of a sports match will depend on effective counteraction to the opponent's actions. (Lv, 2021; Rodrigues et al., 2021; Craig et al., 2011).

Technical and tactical actions in a sports match can be performed from any side and in any sequence. The athlete must distinguish real actions of the opponent from false actions. It is clear that at significant speeds and density of the fight, it is quite difficult to determine threatening actions. In such conditions, demands are growing regarding the balance of mental processes of athletes who conduct a fight (Strelchuk et al., 2022; Ahmedov & Abdulakhatov, 2023).

The balance of the processes of excitation and inhibition allows the athlete to choose adequate technical and tactical messages to counter the opponent. Excitation from a physiological point of view is a nervous process that occurs in every living cell or tissue of any organism as a reaction to irritation. Inhibition is a nervous process that manifests itself in a weakening or complete absence of a response to stimulation. (Uilmor & Kostill, 1997; Mashir, 2002; Rovnij & Rovna et al., 2014). The study of psychophysiological characteristics provides additional information about the functional state of combat athletes, which makes it possible to adjust the training process and improve the quality of their training (Yu & Boychenko, 2023; Li et al., 2021; Rovniy et al., 2018). Measuring the latent period of the visual-motor reaction of like-minded people provides fairly quickly information about the psychophysiological state of the athlete, which is important during the training process (Alesi et al., 2019; de Brito & Silva, 2011). It is believed that all sensorimotor reactions can be divided into simple and complex. Each of these reactions can be considered in the context of three phases: 1) the sensory moment of the reaction - the processes of stimulus detection; 2) the central moment of the reaction is the processing of perceived information, including identification, discrimination, recognition, evaluation and selection of stimuli; 3) motor moment of reaction - processes that determine the beginning of movement (Savchin & Vachev, 2005).

Complex reactions include the so-called "Go/No-go" reaction. The "Go/No-Go" paradigm is a technique used in many psychological, in particular neuropsychological and psychophysiological, studies. In "Go/No-Go" tasks, the subject must respond to one stimulus while suppressing the response to another (Donders, 1969).

The primary challenge remains the development of tests that account for the realities and conditions of competitive fighting, particularly the influence of visual stimuli on the athlete's nervous system. In our study, we began with an analysis of existing methods for measuring sensorimotor reactions and identified their limitations, specifically their inadequate adaptation to the context of martial arts. To solve this problem, we used a methodological approach that incorporated the use of computer technologies for the development of new testing tools. To determine the time of sensorimotor reactions, various methods are used using computer technology on different platforms (Ermakov et al., 2016; Turlisova & Jansone, 2021). The disadvantage of most computer tests is that they do not correspond to the peculiarities of the competitive activity of martial artists in terms of the influence of visual stimuli on the athlete's sensory system. Based on this, we can conclude that there is an interest among sports scientists in the problem of studying sensorimotor reactions, both from the point of view of analyzing the mechanisms of their manifestation, and from the point of view of developing the latest, reliable, proven tests to determine the level of manifestation of various types of reactions.

Purpose of the study. This study aimed to develop a methodology for assessing the "Go/No-Go" reaction for combat athletes using computer technology.

Material & methods.

This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki (protocol of the Commission on Bioethics of the Kharkov State Academy of Physical Culture No. 38).

Participants: The research involved 41 combat athlete (specialization Taekwon-Do ITF), with an average age of 16.5 ± 2.78 years, qualification from 4 Gup to 1 Dan. All participants consented to participate in the study and were informed of its purposes, testing procedures, and the ability to withdraw their consent at any time and for any reason. Participants who have not reached the age of majority were given consent to participate by their parents who were present during the study.

Methods. "Go/No-go" reaction was assessed using a specialized iOS program on tablet computers developed by the departments of martial arts, computer science, and biomechanics of KhSAPC.

Testing procedure. The study was carried out in several stages. At the first stage, the problems of determining the “Go/No-go” reaction in martial arts were considered, a computer program algorithm was developed to determine the level of this type of reaction in martial arts, a mobile application was developed, and preliminary testing was carried out. The “Reaction Go/No-go” mobile application was created for mobile devices running iPadOS, written in Swift using the UIKit, CoreData, AVFoundation, UniformTypeIdentifiers libraries.

The application algorithm allows the test task performer to respond with both hands. The visual stimulus, the blue circle, begins to grow from zero value to the size of the white circle (duration 700 ms), after which two options can occur: either the visual stimulus disappears, or the visual stimulus increases (duration 500 ms). The performer needs to react precisely at the moment when the visual stimulus grows and goes beyond the white circle (Figure 1).

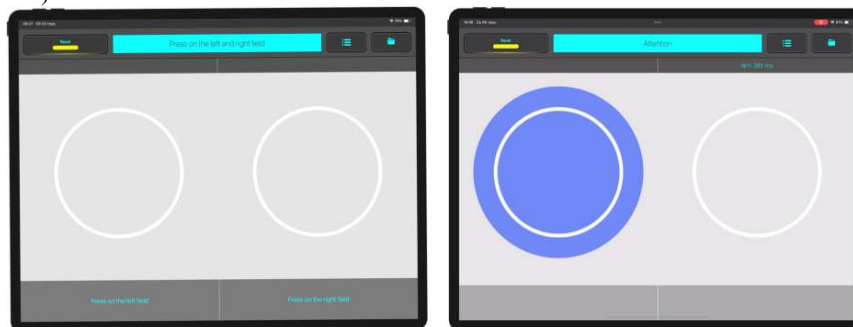


Figure 1. Program interface «Reaction Go/No-go»

At the end of the test, the program checks the obtained data for normality of distribution (Shapiro Wilk test). If the results correspond to the law of normal distribution, the program offers to save the result; if not, then the program offers an additional attempt. The "Reaction Go/No-go" program provides the ability to select testing modes, namely: Random start (visual stimulus appears randomly on the left, right side or simultaneously); Synchronous start (visual stimulus appears simultaneously on the left and right sides). You can also select the range of occurrence of visual stimuli: “2...4 s” (default value); “2...3 s” (less erroneous signals); “1...3 s” (smaller time interval between visual stimuli); “1...4 s” (smaller time interval between visual stimuli, greater number of visual stimuli). In the application settings, you can save a backup copy (“Save backup”) of the measurements taken in JSON format anywhere, add measurements from another device (Add backup, iPadOS operating systems), replace already saved measurements with new ones (“Replace backup”) or delete all data (“Delete all data”). At the first stage of the study, preliminary testing of the “Reaction Go/No-go” mobile application was carried out. To identify errors and settings procedures, software modeling and testing of combat athletes was used. 25 taekwondo athletes with an average age of 15.4 ± 1.69 years took part in this part of the testing. To complete the task of the second stage of the study, namely to determine the reliability, validity and reliability of the proposed methodology, two measurements of the “Go/No-go” reaction were carried out in a group of combat athletes with an interval of three weeks. At this stage of the study, 16 taekwondo athletes with an average age of 17.6 ± 3.87 years took part. The measurement was carried out at the same time in the second half of the day. To activate the sensory and motor mechanisms of movement control, before testing, athletes were asked to perform exercises with tennis balls.

Statistical analysis of the results was carried out using the licensed programs RStudio and Numbers.

Research.

To identify errors in the operation of the mobile application, software simulation of the test exercise was carried out (Random start mode). The following application operating parameters are set: response time range from 240 to 400 ms; the pause between attempts is 1000 ms, the number of attempts in the test task is 20 (Table 1).

Table 1. Results of software modeling at the first stage of the study

Parameters	Ranges of occurrence of visual stimuli (n=20), Mean±SD			
	«2...4 s»	«2...3 s»	«1...3 s»	«1...4 s»
Test duration (s)	132.5±38.9	113.3±32.1	88.9±19.3	131.4±24.5
Demonstration of visual stimuli (right/left hand, %)	46.8 / 53.2	47.5 / 52.5	53.0 / 47.0	49.3 / 50.7
Reaction time (ms)	294.9±11.5	293.7±12.8	292.6±10.9	293.5±11.3

The results of software simulation made it possible to determine the average time to complete a test task using various settings. A uniform distribution of the occurrence of visual stimuli on the left and right hands was also noted (Table 1). Some errors in the testing procedure have been identified.

The results of approbation of the application at the first stage of the study in a group of taekwondo athletes are presented in Table 2.

Table 2. Results of measuring the “Go/No-go” reaction of combat athletes at the first stage of the study (n=25, “Random start” mode, range 2...4 s)

Parameters	Mean	SD	Median	1st Qu.	3st Qu.	Shapiro-Wilk
Reaction time (Left hand, ms)	355.9	34.4	359.1	338.9	376.3	W = 0.98, p-value = 0.86
Reaction time (Right hand, ms)	362.9	23.0	358.7	347.4	378.8	W = 0.97, p-value = 0.62
Errors (Left hand, %)	24.6	16.1	23.1	15.4	35.3	W = 0.96, p-value = 0.33
Errors (Right hand, %)	25.42	15.8	27.3	12.5	35.7	W = 0.96, p-value = 0.45
Test duration (s)	138.1	16.5	135.9	130.1	137.1	W = 0.82, p-value = 0.0004

At the second stage of the study, dedicated to determining the reliability, validity and reliability of the proposed methodology, two measurements were taken in a group of taekwondo athletes (n=16, 17.6±3.87 years) with an interval of 3 weeks. Athletes performed the test in Random start mode, with the range of occurrence of visual stimuli being 1...3 s (Table 3).

Table 3. Results of measurements of the “Go/No-go” reaction of combat athletes at the second stage of the study

Parameters	First measurement		Second measurement		Mann-Whitney’ test
	Mean	SD	Mean	SD	
Integral reaction time (ms)	343.0	24.6	330.7	31.7	V = 92, p-value = 0.231
Reaction time (Left hand, ms)	334.1	31.1	328.1	33.2	V = 77, p-value = 0.668
Reaction time (Right hand, ms)	354.4	22.5	344.0	26.8	V = 100, p-value = 0.105
Integral error (%)	16.1	10.7	17.0	10.5	V = 57, p-value = 0.587
Errors (Left hand, %)	15.5	13.0	14.3	15.5	V = 41, p-value = 0.906
Errors (Right hand, %)	16.0	11.2	19.4	13.0	V = 35.5, p-value = 0.172
Test duration (s)	105.0	18.9	103.9	21.8	V = 4, p-value = 0.789

Based on a comparison of the indicators of the first and second measurements, it can be stated that there are no statistically significant ($p>0.05$) differences between the values (Table 3).

Analysis of reaction times with the left and right hands at the second stage of the study showed that in both the first and second measurements the reaction time with the left hand was better (Figure 2).

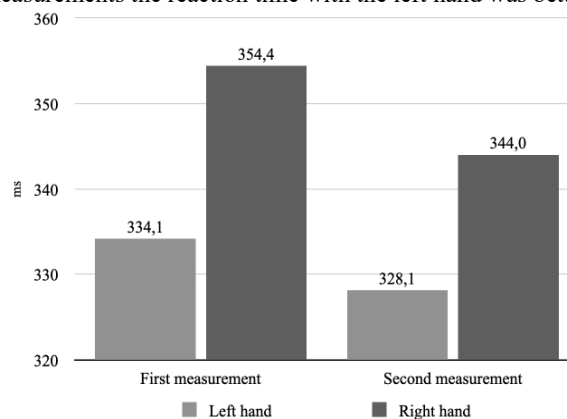


Figure 2. Reaction time at each stage of the test of short-term visual memory in esports athletes of different levels of sportsmanship

Also at this stage of the study, a comparison was made of the reaction time of combat athletes using various modes of performing a test exercise (Table 4, Figure 3).

Table 4. Comparison of “Go/No-go” reaction time of combat athletes in “Random start” and “Synchronous start” modes

Parameter	«Random start»		«Synchronous start»		Mann-Whitney' test
	Mean	SD	Mean	SD	
Integral reaction time (ms)	330.7	31.7	356.9	21.3	V = 6, p-value = 0.00043

It was noted that the reaction time of "Go/No-go" in the "Synchronous start" mode is statistically significantly ($p < 0.05$) longer than when performing the test in the "Random start" mode (Table 4).

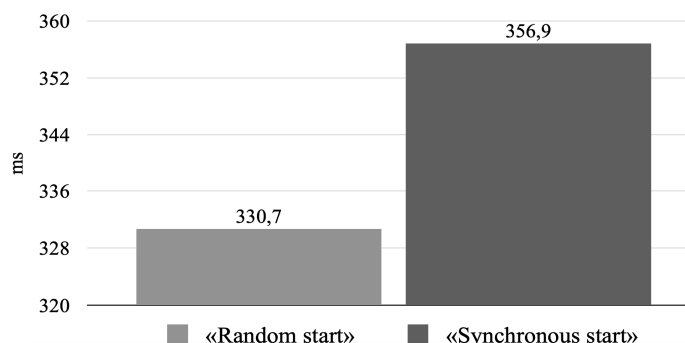


Figure 3. Go/No-go” reaction time of combat athletes in the “Random start” and “Synchronous start” modes

Discussion

Experts determine that one of the main factors for the success of combat athletes in competitions is the level of their technical and tactical preparedness (Tropin & Chuev, 2017; Yaremenko & Pervachuk, 2018; Rodrigues et al., 2021). The combat athlete performs the selection of technical and tactical combinations according to the situations that arise in a sports fight. Almost all of an opponent's actions in a duel include deceptive movements, which prevent them from effectively countering and getting winning points. Gaining an advantage in competition is possible only by taking into account all aspects of interaction with an opponent (Strelchuk et al., 2022; Latyshev et al., 2020). Psychophysiological properties affect the effectiveness of technical and tactical actions during a fight (Myroshnychenko et al., 2020; Korobeinikov et al., 2020; Boloban, 2019). The higher the level of qualification of a combat sports athlete, the higher the level of his sensorimotor reactions. (Romanenko et al., 2019). Assessing the level of visual-motor reactions of combat athletes using modern techniques is of great practical importance for increasing the efficiency of organizing the training process. Simple, reliable and mobile methods that take into account the peculiarities of competitive wrestling of martial artists can not only be a means of obtaining information about the psychophysiological state of an athlete, but also be a means of predicting sports improvement (Romanenko et al., 2022).

The “Go/No-go” reaction is reflected in situations that arise in a competitive match, when a combat athlete needs to act only on real threats and suppress his activity in response to the opponent's erroneous actions. It is this balance that can be observed in highly qualified athletes who have a perfect mechanism for controlling their movements, taking into account incoming information from analyzers. (Dakal, 2015; Romanenko et al., 2019). Carrying out any measurement dedicated to determining the time of the visual-motor reaction in any complexity requires concentration and attention from the performer. It should be noted that there is a need for motivation and interest of those who perform the test task. This can be done by different means. In the study, in order to activate the sensory and motor mechanisms of movement control and create positive motivation, before testing, athletes were asked to perform exercises with tennis balls, namely different ways of juggling.

In the “Reaction Go/No-go” application, a correction of measurement results has been introduced. In cases where the test results do not correspond to the law of normal distribution from the data array, the worst result will be removed and an additional attempt will be added. This algorithm of program behavior allows the performer to show the result that best suits his capabilities.

Analysis of the results of preliminary testing (the first stage of the study), namely software modeling, indicates that performing a test exercise with the choice of the range “1...3 s” has an advantage due to its shorter duration (“1...3 s” – 88.9 ± 19.3 s; “2 ...4 s” – 132.5 ± 38.9 s). It should be noted that the duration of a round in competitive fights, in most striking types of martial arts, is 2 minutes. The duration of the test exercise with a range of 2...4 s of the appearance of visual stimuli is as close as possible to the duration of the round. Performing a test exercise with the choice of this range increases the duration of the test exercise by approximately 20-25% (compared to the range “1...3 s”), which in turn increases the intensity of nervous processes and this may be useful when studying this type of reaction in qualified combat sports athletes.

According to Hick's law (Hick, 1952), the average reaction time is a linear function of average uncertainty (or information entropy). At the same time, uncertainty grows logarithmically with the number of alternatives. That is, the more information you need to process, the longer the reaction time will be. In a study of choice reactions (Romanenko, 2022), where it was necessary to respond to various geometric shapes, similar conclusions were drawn. Thus, the reaction time for the sphere was the shortest, and for the cube the longest. A cube is a complex figure compared to a sphere; it has the largest number of elements (angles) to define it. A comparison of the "Go/No-go" reaction time in the "Random start" and "Synchronous start" modes also confirms that the amount of information affects the reaction time. In the "Synchronous start" mode, before the time of detection of the visual stimulus, the time to distinguish the visual stimulus, and the time of motor execution, more time will be added to determine which hand will perform the motor action. This mode of performing the test exercise is more complex. It can be used when studying this type of reaction in qualified combat athletes. Based on the research procedure to determine the reliability, validity and reliability of the results (Bazylevych, 2018; Middleton, 2023) the second measurement of the "Go/No-go" reaction time of combat athletes was performed three weeks later. As for the reliability and ease of use of the proposed computer program, testing has shown that the algorithm of its operation is easily understood by athletes of all ages and qualifications. Analysis of the problems of validation allows us to determine that the main attention in this process is on the interpretation and use of test results (Kane, 2006). Validity (English validity, French validité – suitability (validity, legality, weight, validity), from Latin validus – "strong, healthy, worthy") – the validity and suitability of the application of research methods and results in specific conditions.

The argument-based approach to validity can be simplified. It can be made more accessible to practitioners by eliminating the need to develop an interpretation/use argument. If test developers properly articulate the intended purposes of test items, there is no need for an interpretive argument. Tests must be designed to fulfill one or more intended purposes (Sireci, 2013).

From the point of view of the purpose of passing the test task, which allows you to determine the "Go/No-go" reaction time, it has a clear formulation, namely: "Quickly react to the moment when the blue circle goes beyond the white. In other cases, do not react." That is, the test exercise measures the performer's ability to respond to only one stimulus while suppressing the response to another, which corresponds to the Go/No-Go paradigm. The Reaction Go/No-go app's algorithm is designed to prevent misuse of the test. A clear structure of the test exercise, the necessary settings (test mode, number of attempts, range of occurrence of visual stimuli) and their display in the test results prevent this. This allows you to select results with appropriate settings after conducting the study, which gives objectivity to the testing results.

Comparison of the results of the first and second measurements at the second stage of the study showed that there are no statistically significant ($p > 0.05$) differences between the values. This indicates the stability and consistency of the measurement results and that the results of this test exercise can be reproduced after a specified period of time (Middleton, 2023).

Conclusions

The complex sensorimotor reaction "Go/No-Go" is one of the main types of reaction in martial arts. The balance of the mental processes of athletes conducting a fight affects the efficiency and economy of their technical and tactical actions, and this, in turn, affects the final result in competitions. A method has been developed for assessing the level of manifestation of the "Go/No-Go" reaction for combat athletes using modern technologies, namely mobile devices running iOS, iPadOS. The study of the "Go/No-Go" reaction with the choice of various application configuration modes made it possible to determine the features of passing the test exercise. Thus, performing a test exercise with a choice of the range "1...3 s" of occurrence of visual stimuli has an advantage due to its shorter duration, which is important for group testing. The duration of the test exercise with the range "2...4 s" is as close as possible to the duration of the rounds in most striking types of martial arts, which can be useful when studying this type of reaction in qualified combat athletes.

Analysis of the research results indicates that the proposed method for determining "Go/No-Go" reaction time is reliable, valid and reliable. The relevance and significance of the study lie in addressing the practical need for a reliable and adaptable method to assess sensorimotor reactions in combat sports, specifically the "Go/No-Go" reaction, which plays a critical role in competitive performance. The developed methodology has theoretical importance, as it contributes to the understanding of the psychophysiological mechanisms underlying sensorimotor responses in athletes. From a practical perspective, the proposed approach offers a user-friendly, technology-driven tool for both individual and group assessments, ensuring efficient integration into training and evaluation processes.

The results of this study provide valuable insights for coaches and sports psychologists, enabling them to tailor training programs to enhance athletes' reaction times and decision-making abilities. The application of modern mobile technologies ensures accessibility and scalability, making the methodology applicable across various combat sports disciplines. Further research should focus on refining the testing configurations to explore other reaction types and their implications for performance. Additionally, longitudinal studies are recommended to evaluate the long-term impact of reaction training on competitive outcomes.

Conflict of interests

The authors declare that there is no conflict of interests.

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