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Use of psychophysiological computer tests during the process of sportsmen's preparation

Pszicho-fiziológiai teszt alkalmazása a sportolók felkészítésében

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Abstract - Psychophysiological computer tests are widely accepted in sports science, because they are fast and not expensive. In this study, a new program for computer testing is presented which allows us to find the average reaction time of a sportsman in different directions and estimate his/her reaction symmetry coefficient. On the basis of these parameters recommendations to coaches and sportsmen are given for the future training. The main feature of the program is its design perfectly fitted into reality which contributes to more effective and persistent changes in the reaction skills of a sportsman. On the example of a group of ten 17-19 year old sportsmen with low-medium qualification the improvement of choice reaction time by 10% on the average is demonstrated one-month after a special training including the computer tests for about 10-15 minutes daily. The method has proved to be effective for improving sportsmen's reaction, attention, concentration, coordination and peripheral vision and should be taken by athletes regularly to develop fine motor skills. Tests for other sports, like basketball, handball and rugby are also included.
Keywords: reaction time, response time, visual reaction, peripheral vision, psychophysiological test

Absztrakt - A komputerizált pszicho-fiziológiai tesztek egyre elfogadottabbak a sporttudományban, mivel gyorsak és nem túl drágák. Jelen tanulmány célja egy újfajta számítógépes program bemutatása, amely az átlagos reakcióidő mérésére alkalmas különböző irányú mozgások esetén, és így alkalmas a sportolók reakció-szimmetria együtthatójának becslésére. E paraméterek alapján javaslatokat fogalmazunk meg edzők és sportolók számára a jövőbeli edzésmunkára vonatkozóan. A program legfontosabb tulajdonsága, hogy a valósághoz teljes mértékben illeszkedik, és így pontosan tudja mérni a sportolók reakcióképességében történő változásokat. Ennek egy példáját mutatjuk be, egy tíz főből álló, 17-19 éves sportolókat tartalmazó csoportban, 1 hónap után mérhető 10%-os elmozdulás kapcsán, mely napi 10-15 perces tesztelés után következett be. A módszer hatékonynak bizonyult a sportolók reakciójának, figyelmének, koncentrációjának, koordinációjának és perifériás látásának fejlesztésére, és így hasznos eszköze lehet a finommotoros készségek fejlesztésére. Az eszközt más sportágakkal, kosárlabdával, kézilabdával és rögbivel kapcsolatban is érdemes alkalmazni.
Kulcsszavak: reakcióidő, válaszidő, vizuális reakció, periferikus látás, pszicho-fiziológiai teszt

Introduction

The speed of reaction in sports is of great importance. Often success depends on how timely and rationally the athlete reacts to changes in the competitive situation or how timely he performs the starting action (Macovei et al., 2013; Senel & Erogly, 2006) and, moreover, prolonged reaction time may substantially increase susceptibility to injury (Wilkerson et al., 2017). The speed of reactions can be improved with the help of special exercises (Lemmink & Visscher, 2005; Savas & Ugras, 2004).

The typical visual reaction time is around 0.2

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to 0.3 seconds. Audio reaction time is generally 30 to 50 milliseconds faster (Shelton & Kumar, 2010). Factors that may influence the performer's reaction time are: gender and age, psychological state, level of fitness, number of possible responses, time available, intensity of the stimuli, experience, health, body temperature (the colder the slower), personality (extroverts react quicker), state of alertness or length of neural pathways. It is well-known that athletes have better reaction time than non-athletes (Akarsu et al., 2009; Atan & Akyol, 2014; Ghuntla et al., 2012; Jyothi et al., 2016), that men are faster than women (Baur et al., 2006; Heirani et al., 2012; Jain et al., 2015; Spierer et al., 2010; Tønnessen et al., 2013), that tired people react slower than well-rested ones (Aydin et al., 2016) and that in children the reaction improves with age (Montes-Mico et al., 2000).

And, of course, the reaction time depends on the type of reaction: simple reactions are characterized by a single signal and one previously known response action. Complex reactions are determined by two or more signals, and one or more responses. Complex reactions are typical for all sports, where there is competition between rivals (boxing, fencing, fighting and sports games like soccer, basketball, handball and rugby).

Representatives of these sports, as a rule, have a significant arsenal of methods of attack, defence, deceptive actions, but they don't know in advance how to behave at the moment, which response to carry out, therefore, and their reactions are a subject of choice. Choice reactions have a longer latency compared to simple reactions, resulting from a large amount of information entering the brain and requiring processing (Tønnessen et al., 2013). Reaction time can be measured using computers, which have become an indispensable component of sport. In addition to many other possible applications, computers allow us to obtain objective information about the psychophysiological state of the athlete with the help of special tests. Such tests are successfully used to measure simple and complex reactions of athletes (Ashanin & Romanenko, 2015; Chitashvili et al., 2006; Egoyan et al., 2005, 2014; Kirkitadze et al., 2007).

In addition, it should be mentioned that there is an increased interest to computers among athletes: many athletes are learning the nuances of their sports in computer games. Scientists have proved that playing computer video games for 10-15 minutes a day has a positive effect on the process of sportsmen's preparation (Blumberg & Fisch, 2013; Dye et al., 2009; Green & Bavelier, 2003).

There are many scientific papers describing how athletes' reaction depends on age, gender, physical fitness and psychological state. At the same time, it is not sufficiently studied how the reaction varies depending on the direction of signal arrival in space and whether the design of the computer program affects the testing process. Researches show that athletes have a significantly shorter response time to stimuli appearing in the peripheral field of vision compared to non-athletes (Ando et al., 2001; Zwierko, 2007). Some scientists also point to the possibility to improve peripheral vision by means of specific visual training programs (Williams, 2003). The purpose of this study is to create and implement a comprehensive method of computer testing to determine the simple and complex visual reactions of an athlete and to study how the reaction depends on factors such as the direction and the frequency of signals. In addition, the possibility of using computer tests to improve and correct the reaction of athletes is explored and the role of the program interface in this process is clarified. The method is intended for selection and optimization of the training process of athletes and is a result of a long-term work of Georgian scientists (Chitashvili et al., 2006; Egoyan et al., 2005, 2014; Kirkitadze et al., 2006).

Method of Computer Testing

The testing program represents a computer interface which studies the speed of the sportsman's reaction upon a virtual sportsman's position change on the computer screen. There are four positions available on the screen. The positions lie on the horizontal line symmetrically from the left to the right and are separated by equal distances (see Fig.1). Two tests are used:

1. Test №1 for measuring the simple reaction time - the tested sportsman should react by pressing one button;
2. Test №2 for measuring the choice reaction time is more complicated - the tested sportsman should pass a virtual ball to the virtual sportsman by pressing one button out of the four buttons corresponding to the position of the virtual sportsman.

Figure 1. Interface of the computer program.

The number of passes varies from 20 to 100, the time interval between passes lies in the interval 0.5-2.0 seconds. The design of the program is perfectly fitted to reality which contributes to more effective and persistent changes in the sportsmen reaction skills. Besides football we include tests for basketball, rugby and handball. All photo images used for the program design can be easily changed and replaced by any other images depending on your taste. One can use his/her own photos as well as free images from the Internet.

The tests allow to estimate the sportsman's simple motor visual reaction and his choice visual reaction in different directions. Each position change is interpreted as a mini-test. The numbers of mini-tests in all directions are the same. The time interval between mini-tests may be constant or it may vary randomly within a range set by the user. The lower and upper borders of the range lie in the interval 0.5-2.0 seconds.

The program has options to make some positions on the screen inactive. There are four options to do that: positions P_1 and P_2 stay active, positions P_3 and P_4 stay active, positions P_2 and P_3 stay active, and the fourth possible variant is when positions P_1 and P_4 are active. These tests are used when a tested person has problems with reaction symmetry or peripheral vision.

Tests with a neutral green background can be also applied, where a round white figure should be placed into the round white circle by pressing one from the four buttons corresponding to the position of the circle. This test is needed to understand how test results depend on the background design.

On the basis of computer testing the following parameters are calculated:

1. Average reaction time T_{av} in all directions and average reaction times T_1, T_2, T_3 and T_4 for each direction separately.
2. The number of incorrect responses M_{av} in all directions and the number of incorrect responses M_1, M_2, M_3 and M_4 for each direction.
3. Reaction time symmetry coefficient $S=((T_4-T_1)/ T_{av})\cdot 100\%$.
4. Peripheral vision coefficient $[((T_1+T_4)/2-(T_2+T_3)/2)/T_{av}] \cdot 100\%$
5. Reaction time standard and mean deviations (SD and MD).
6. Reaction time variance coefficient V.

The process of computer testing can be divided into the following stages:

Stage I is a preparatory stage: at this stage teenagers are selected for testing. At this stage, the test groups are formed, tests are scheduled for testing based on basic tests, a database is created

and data about the test groups are entered. Data on teenagers (name, surname, group type, age, height, weight, qualification, address and contact information) are entered into the database using a special computer program. Each teenager is assigned a unique identification code, according to which it is possible to uniquely identify his test data in the future.

Stage II - testing of sportsmen with a computer program is carried out. The program calculates the values of the test interval (reaction time), the coefficient of symmetry of the reaction and a number of other parameters. Before testing, sportsmen should be instructed and do trial testing. They get acquainted with the testing program and conduct various tests until they begin to feel free with the computer. The psychological state of the sportsmen is also important: fatigue after training, excitement after the game or just a lack of time can badly affect the results of testing. Reaction time may be also influenced by such factors as time of the day - for example, in the evening you can expect lower results than in the morning or afternoon. This is why sportsmen are instructed to avoid maximal exercise for 24 hours, and consumption of caffeine and heavy meals 2-3 hours before testing (ACSM, 2006).

Stage III - at this stage, the test data are entered into the database in one of the data formats suitable for subsequent analysis in the statistical program SPSS.

On the basis of statistical analysis of the collected data, the teenagers having problems with reaction time are recommended to undergo computer training according to the training programs with parameters specially selected for them. In addition, their coaches are informed about existing problems, so that they could take the appropriate measures: change the playing role, reduce the load, or change the training exercises. And, on the contrary, the teenagers with good results will be recommended to meet the trainer, and, in case of mutual consent, seriously engage in sports.

On the basis of the analysis of testing data, computer training for sportsmen is developed, if necessary. In case of expressed problems with reaction time or reaction symmetry, a training program should be developed individually for each football player, taking into account the problems of the teenager. For example, the frequency of mini-tests is increased if the problem is connected with reaction time or some directions are made inactive if the problem is with the reaction symmetry coefficient. If during the testing there was fatigue (which may be recorded by the heart rate indicators), the reduction of the number of mini-tests and the duration of the test are recommended.

Actually, the testing program and the training program represent the same program. In the process of computer training, the same program is used as for testing, but with individually chosen parameters (the number of mini-tests, the frequency of mini-tests, etc.).

Depending on the problems of a sportsman concerning visual reaction and peripheral vision, besides our tests the coach can use the exercises and methods listed below in different proportions.

a. Trial games: during this exercise, the team is subdivided into two teams, which play against each other. The goal is that the players are given the possibility to change their role, change flanks, etc. The exercise contributes to formation of versatile football players.
b. Grids 4v2, 5v3: this exercise improves attention, concentration, reaction and field vision.
c. Small sided games, 5v5, 6v6, 7v7: during this exercise players learn to make quick decisions in the conditions of more intensive game on a small football field.
d. Playing standard positions and taking penalties, free kicks and corner kicks.
e. Use of psychological methods.

Stage IV - on the basis of the analysis of the results obtained, the criteria for selection and orientation (the playing role) were identified individually for each teenager and recommendations were given to coaches how to correct the training process.

The main features that distinguish the program from similar programs of this type are:

1. A realistic graphical interface that facilitates better learning skills acquired during testing.
2. The ability to measure the reaction time in different directions, which is more in line with the situation on the field.
3. The possibility of performing mini-tests in asynchronous automatic mode, which contributes to the development of the athlete's ability to concentrate for a sufficiently long period of time: the entire test lasts

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approximately 20-40 seconds, which is comparable to the average duration of a game situation in football (from several seconds to several minutes).

There are many on-line programs in the Internet which can measure simple and choice reaction times and may be used for visual reaction trainings but they all lack the features listed above.

The new computer program is the improved version of the old program which was successfully used during the process of preparation of young football players when more than 150 young took part in the computer testing (Egoyan et al., 2014). The new program measures reaction times in different directions, gives a better interpretation of the game, has a better interface adjusted for large displays.

Before starting the testing described in this paper a trial testing had been conducted during which 30 young sportsmen aged 17-22 were tested. The trial testing served for optimization of the process of testing and a better understanding of sportsmen's possibilities.

Results and Discussion

For the testing, 10 young men (aged 17-19) attending the college at the University of Sport of Georgia and the University of Sport were randomly selected. All the young men specialize in football, but they had never participated in computer testing of the reaction and had not specifically been engaged in the process of improving their own reaction. 9 of them had a low qualification but one sportsman was prepared at the level of candidate of master of sports. Preliminary testing showed that they had a wide spread in the times of simple and complex visual reactions and, consequently, high enough average times of both reactions: 259.30±21.04ms (milliseconds) - the average time of simple visual reaction (Test №1 for simple reaction time was used) and 471.60±15.32ms - the average choice reaction time (Test №2 for choice reaction time was used). Here, and later in this paper, average reaction times are followed by mean absolute deviations. The number of mini-tests in both tests n was equal to 40, the frame rate f varied from 500ms to 1500ms. These results are significantly poorer than the reaction times measured for athletes and reported in the scientific literature (Heirani et al., 2012; Jyothi et al., 2016; Savas & Ugras, 2004; Tønnessen et al., 2013).

The analysis of existing experimental data describing simple and choice reaction times made it possible to find reaction times compatible with each other and with the results: for example, Tønnessen reports 0.166 ms simple reaction time for world-class sprinters (Tønnessen et al., 2013); according to Jyothi, simple reaction time for experienced runners is about 185.9 ms and for non-athletes - 272.00 ms (Jyothi et al., 2016); Savas and Ugras' studies show that the average visual reaction time of young taekwondo athletes is 209.47ms (Savas & Ugras, 2004); and Heirani reports 435.26 ms mean choice reaction time for non-elite male athletes and 402.95 ms for elite male athletes (Heirani et al., 2012). Based on these data and the data collected during the trial testing a scale for estimation of simple and choice reaction times was created (see Table 1).

Table 1. Scale for estimation of simple and choice reaction times.

	Simple reaction time (ms)	Choice reaction time (ms)
Very good	<190	<370
Good	190-210	370-400
Normal	210-230	400-435
Not bad	230-270	435-470
Bad	270-300	470-500
Very bad	>300	>500

Unsuccessful test execution can be explained by the inability of the young men to concentrate, insufficient flexibility of the visual focus and insufficient coordination of attention.

All the young men were recommended to undergo monthly computer training according to

the following program:

1. Trainings – every day for 10-15 minutes including relaxations between tests.
2. The following tests should be performed (see Table 2):
    1. Test № 1 for simple reaction time - 3 tests containing 40 mini-tests each with the time interval between mini-tests 500 ms with a total duration of 1 minute.
    2. Test № 2 for choice reaction time - 3 tests containing 40 mini-tests each with the time interval between mini-tests 500 ms with a total duration of 1 minute.
    3. Test № 1 for simple reaction time - 3 tests containing 40 mini-tests each with the time interval between mini-tests 500-1500ms with a total duration of 2 minutes.
    4. Test № 2 for choice reaction time - 3 tests containing 40 mini-tests each with the time interval between mini-tests 500-1500 ms with a total duration of 2 minutes.
    5. Test № 1 for simple reaction time - 4 tests containing 20 mini-tests each with the time interval between mini-tests 1000-2000 ms with a total duration of 2 minutes.
    6. Test № 2 for choice reaction time - 4 tests containing 20 mini-tests each with the time interval between mini-tests 1000-2000 ms with a total duration of 2 minutes.

These tests allow to measure both simple and choice reaction times for periodic and a periodic frame rates and for different numbers of mini-tests (20 and 40). This set of tests is supposed to improve the sportsman's ability to adopt better to different game tempos and different game paces.

Table 2. Test parameters for computer training.

№	Test	Mini-tests number	Min. frequency (ms)	Max. frequency (ms)	Number of tests	Duration (min)
1	Test №1	40	500	500	3	1
2	Test №2	40	500	500	3	1
3	Test №1	40	500	1500	3	2
4	Test №2	40	500	1500	3	2
5	Test №1	20	1000	2000	4	2
6	Test №2	20	1000	2000	4	2
	Total:				20	10

The procedures of visual reaction computer testing and training have been developed taking into account our previous experience. The number of mini-tests, the frequency of mini-tests, the duration of trainings and other parameters were selected in order to achieve maximum effectiveness and accuracy.

3. The number of incorrect responses during the test should not exceed 10% of the whole number of mini-tests n in the test. For $n = 40$, the allowable number of errors is 4. Incorrect responses aren't included in the calculations of average reaction times and other test parameters. If a number of errors exceed the allowed limit then the test is abandoned with no result. It should be noted that well-trained sportsmen usually perform tests without errors.

The tested person was given three attempts to pass the control test. The attempt with the best testing time after checking for normality according to the criterion of Shapiro-Wilk was recorded into the database.

The training test parameters are shown in Table 2. It can be seen that the total test duration is only 10 minutes. In this case, it is recommended to make small breaks of about 10-20 seconds between individual tests, and sportsmen are allowed to add tests at their own discretion: so, the total duration of tests increases to 10-15 minutes.

According to the appointed training program, the students underwent a month-long training for

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10-15 minutes daily. Table 3 demonstrates how the distribution of athletes according to the scale shown in Table 1 has changed after the training.

Regarding the reaction time symmetry coefficient S, it should be said, that it is unstable and depends on the concentration level of the sportsman and his ability to control all active positions on the computer screen simultaneously. A sportsman may concentrate on one direction and achieve a very good reaction time in that direction. But this will be done at the cost of reaction times in other directions. In order to correct reaction symmetry, the direction is made in which the sportsman has the best result inactive thus forcing him to change his attention focus. Just like in the previous works (Egoyan et al., 2014; Kirkitadze et al., 2007) it was accepted that sportsmen have no problems with reaction symmetry if their S<=10%. If before the training 7 sportsmen had problems with reaction symmetry, after the training only 3 sportsmen stayed in the problem group. The peripheral vision coefficient P also depends on the ability of the sportsman to control all directions simultaneously. This coefficient is connected to coefficient S because S is proportional to the difference between the reaction times in peripheral directions P_1 and P_4. This means that if the sportsman's reaction times decrease in these directions then the greater reaction time will decrease faster and both coefficients S and P will decrease. This happens because visual reaction in the central directions is usually better than in the peripheral directions (Ando et al., 2001; Williams, 2003; Zwierko, 2007). Just like in the case with S the norm for P was set in the range of 0-10%. P also improved after the training: from 8 sportsmen having problems only 2 stayed in the problem group (see Table 4).

Table 3. Distribution of athletes according to scale presented in Table 2.

	Simple reaction time		Choice reaction time	
	Before training	After training	Before training	After training
Very good	0	0	0	0
Good	0	1	0	1
Normal	1	4	0	3
Not bad	5	5	2	2
Bad	4	0	8	4
Very bad	0	0	0	0

Table 4. Reaction parameters before and after computer training.

	Before training	After training
Simple reaction time (ms)	259.30±21.04	227.30±16.67
Choice reaction time (ms)	471.60±15.32	424.50±20.10
Deviations of symmetry coefficient S (persons)	7	3
Deviations of peripheral vision coefficient P (persons)	8	2

As a result of computer training using the method, the average performance of the group improved significantly: the average time for a simple visual reaction in four directions was reduced by 12% to 227.30±16.67ms, and the average choice reaction time improved by 10% to 424.50±20.10ms. At the same time, 4 students could not overcome the barrier of 435ms, set for the reaction of choice. Three of them had also problems with the symmetry coefficient and two with the peripheral vision coefficient. Analysis of the data of these students showed that they did not conduct trainings regularly and this seems to be the reason for their failure. It was indicated to the trainer to pay attention to their discipline. The coefficients of symmetry of reaction time S and

peripheral vision P for other students corresponded to the norm, established in the range of 0-10%.

The research clearly demonstrated that the reaction time depends on sportsmen's qualification: the best sportsman had also the best reaction times: the simple reaction time 226 ms before the training and 205 ms after the training and the choice reaction time 476 ms before and 395 ms after the training. His choice reaction times for different directions are shown in Fig. 2.

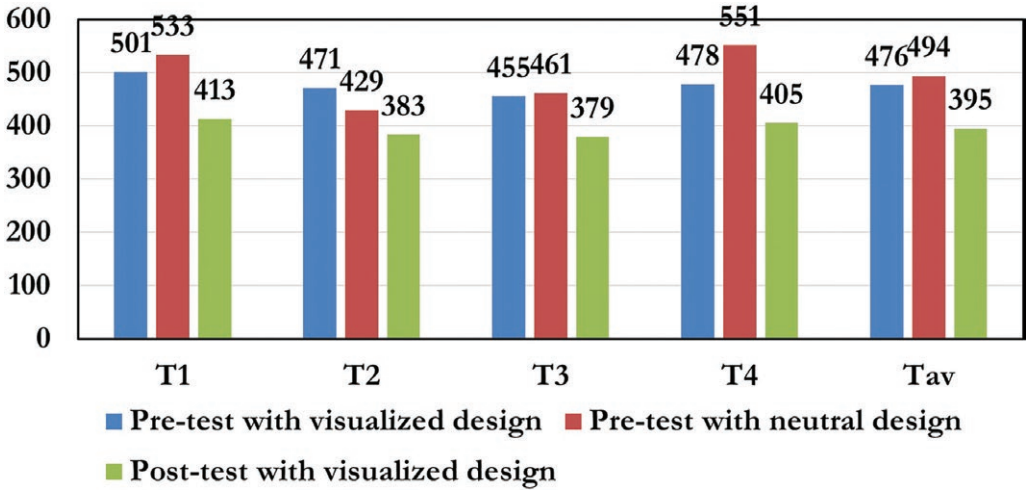

Figure 2. Pre- and post-test results for the best sportsman.

In general, the method has proved to be effective, and attention has been drawn to the following considerations:

1. The use of visualized backgrounds contributes to more effective and persistent changes in the reaction skills of a sportsman. The program has more pronounced effect on sportsmen when run on large screens.
2. Sportsmen should practice reaction improving tests regularly - otherwise the reaction will get worse and the acquired skills begin to weaken.
3. Prolonged training does not lead to an improvement in response: it is enough to perform computer tests 10-15 minutes a day including relaxations between tests. This conclusion is based on previous experience. It was noticed that prolonged trainings cause fatigue and make sportsmen feel bored.
4. The reaction time in the case of a periodic tests (n = 40, 500 ms ≤ f ≤ 1500 ms) is on average by 10-15 milliseconds greater than in the case of periodic tests (n = 40, f = 500 ms).

Conclusion

In th study, a method for assessing and correcting the visual reaction of athletes using computer testing is described. The computer testing program contains elements of video games making it more attractive for young sportsmen. The computer interface of the program reminds the tested sportsman of his favourite sport and makes the process of learning faster and more productive.

The example of a group of 10 students aged 17-19 who are engaged in football at not professional level demonstrates an improvement in the choice visual reaction time by 10% on the average as a result of one-month trainings for 10-15 minutes daily.

The tests have proved to be effective for improving sportsmen's reaction, reaction symmetry and peripheral vision and should be taken by athletes regularly to develop fine motor skills.

The technique requires from athletes to be able to keep the state of higher awareness for sufficiently long time and indirectly serves to improve attention, concentration and self-control of athletes, their coordination and to increase the flexibility of their attention focus. All these qualities are of great importance for the achievement of success in sport. Considering all the above, it can be stated that such a technique deserves special attention of coaches and athletes and not only in football, but also in such sports as rugby, basketball and handball. The method is good for sports where sportsmen's

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attention is distributed in different directions. In future it is intended to measure reaction times of football players with mental disabilities and we plan to create a similar program for measuring audio reaction times of blind football players.

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