Original Article

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# Influence of typological features of the nervous system on individual performance in running for short distances in athletes with visual impairment on the example of an elite athlete

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

## Abstract

*Introduction*: The purpose of the work is to theoretically and experimentally substantiate the influence of psychophysiological factors on individual performance in athletics sprint in high-qualified athletes on the example of an elite athlete. *Material and methods:* In this study, participated 1 athlete, 36 years of age, female. Athlete is specializing in short-distance running and long jump, the European Athletics Champion 2010; prize winner of the World Paralympic and Paralympic Games among athletes with visual impairments (T12 category) in 2016. The study was conducted for 5 months. Twice a week, testing was conducted (psychophysiological indicators and running speed); 36 tests of one athlete were conducted. Individual characteristics of the psychophysiological state and results in running for 100 m for five months were analyzed. *Results.* The models of multiple linear regression between results in 100 m run for an elite athlete with visual impairment and psychophysiological indices are compiled. High importance of psychophysiological indices in individual performance in running on 100 m is shown. *Conclusions.* Compensatory mechanisms of visual function deficiency were established to maintain high speed in the 100 m run as psychophysiological functions: indicators characteristic of sprinters (speed of simple reaction and motility of the nervous system) and specific indicators (efficiency, strength of the nervous system).

**Keywords:** sprint, track and field athletics, vision, limited possibilities, psychophysiological functions.

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# INTRODUCTION

Currently, achievements in track and field athletics are approaching the peak of human capabilities [1,2], and the training process in the sport of higher achievements reached the maximum values of volume and intensity of physical exertion [3,4]. Therefore, the search for ways to improve the efficiency of the training process by optimizing the training process without increasing the volume and intensity of the loads, and also by taking into account and applying the training factors to enhance the sporting skills is of particular relevance. The disclosure of the physiological and psycho-physiological factors of sporting achievements becomes especially topical.

Psychophysiological opportunities and typological features are inherent characteristics, and therefore are one of the main factors that determine the main aspects of sports training [5].

A quantity of studies have shown the expediency of taking into account the psychophysiological capabilities of athletes for determining individual styles of wrestling in martial arts [6], in sports games [7,8] and in other sports of the sport [9,10].

Ilyin [11,12] critically notes that until now, for example, the point of view is expressed that for sporting success it is advantageous to have a strong, mobile and balanced nervous system.

In those sports where speed is one of the main factors determining the success of sports activities, athletes with experience in most cases have a "sprint" typological complex. It is found in sprinters of track and field athletes, fencers, acrobats, sprinters-cyclists, table tennis players [11].

Finally, in sports that require the manifestation of speed endurance (for example, in running for 400 m), most athletes have a strong nervous system [12,13], the average mobility of nervous processes, the predominance of excitation by internal balance, that is, a typology conducive to the manifestation of tolerance for fatigue [12,13].

Each psychomotor ability can be caused by many makings (in our case - typological features), which allows us to talk about typological complexes that determine this or that ability. Thus, the speed capabilities (short response time to the signal, rapid muscle contraction and high maximum rate of movement) are due to the combination of a weak nervous system with the mobility of the nervous processes and the predominance of excitation or balance of the nervous processes in the external balance. The more the athlete has these typological features (and the presence of all of them in the person is not necessary), the more likely that he expresses the speed abilities [5,11,12].

According to the theory of functional systems, Anokhin [14-16], the general scheme of the relationship between running speed and perception of the surrounding space can be represented as follows. The central nervous system receives signals from muscle proprioceptors about the intensity of muscle contractions. At the same time, the central nervous system receives signals from the visual analyzer about the surrounding environment. Due to these signals, the direction of the run is regulated, as well as its speed. If the environmental conditions are relatively stable, as, for example, on a treadmill, the body concentrates its efforts solely on running speed. If the environmental conditions change, as, for example, when running on rough terrain, in different weather conditions, the speed and direction of the run varies.

In the case when the information from the visual analyzer is insufficient, what happens in the case of a deficiency of visual function, the signaling about danger during running is activated in the brain due to insufficient information about the surrounding space [17]. As a result, the process of development of the maximum speed of movement is blocked, which negatively affects the sports result. Athletes with visual impairment are more difficult than healthy athletes to develop the maximum running speed because of the blockage of speed from the central nervous system.

Partial or complete solution of this problem lies in the activation of compensatory mechanisms in the absence of visual function.

As compensatory mechanisms may be an increased perception of signals from the auditory receptors, from the proprioceptors of muscles, may develop to a greater extent than the healthy athletes such specific feelings as "track feeling", "sense of distance", etc. These signals can be fully or partially block the danger signals associated with a lack of visual information, and provide the running speed, characteristic for the capabilities of the motor apparatus (Figure 1).

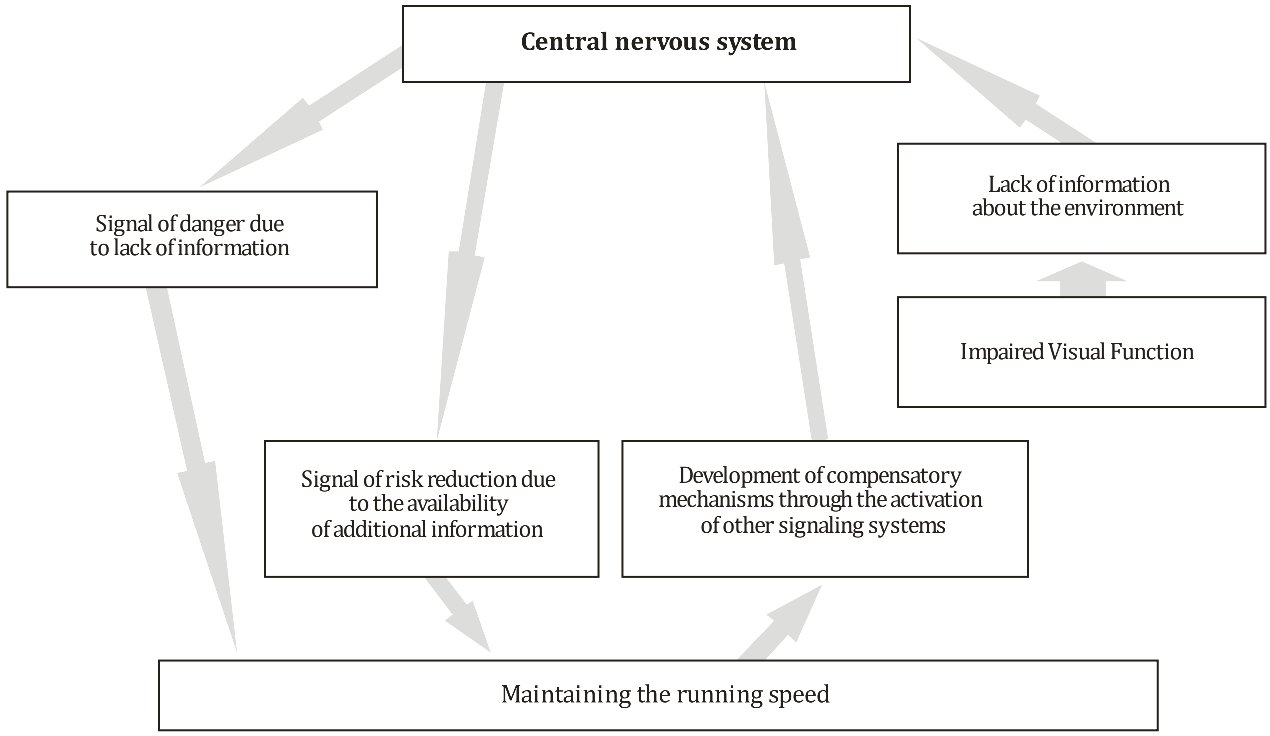


Figure 1. Scheme of compensation for the inadequacy of the function of the visual analyzer in regulating the speed and direction of the run, depending on the visual perception of the surrounding space (source: the figure of the authors).

It is logical to assume that with the development of psychophysiological functions specific to a particular person, compensatory mechanisms will develop to reduce the lack of visual analyzer. For this, it is necessary to identify psychophysiological factors associated with running speed. This will enable a deeper understanding of the mechanisms of regulation of running speed in people with limited visual function and a more optimal selection of tools and methods for building the training process of sprinters with visual impairment. For example, with pronounced mobility of the nervous system, at a high reaction rate, it is advisable to focus on the development of the starting speed, on the development of the ability to change the degree of tension and relaxation of the muscles. With the expressed strength of the nervous system, it makes sense to concentrate on maintaining the speed at a distance. Development of strengths of the athlete will give additional information to the central nervous system about the movement of the athlete, as a result of which the danger signaling will be blocked due to the lack of a visual analyzer, and the speed of the athlete's run will not decrease.

Despite the fact that modern research has already attempted to characterize athletes - representatives of different sports in terms of typological features of the nervous system, the actual task is to determine the psychophysiological indicators and typological characteristics individually for each athlete [18-21]. This is due to the fact that individual psychophysiological differences can be so pronounced that they will determine the necessary set of means and methods for training athletes.

Especially this problem is relevant for athletes with disabilities [17], in particular, for athletes with a limited vision. In this study, it was suggested that: 1) there are psychophysiological factors that determine the athletic result individually for each athlete; 2) athletes with visual impairment increase the influence of psychophysiological factors as compensatory mechanisms of limited visual opportunities.

The purpose of the work is to theoretically and experimentally substantiate the influence of psychophysiological factors on individual performance in athletics sprint in high-qualified athletes on the example of an elite athlete.

# MATERIALS AND METHODS

*Participants*

In this study, participated only 1 athlete. Participant was tested many times during 5 months. Athlete is specializing in short-distance running and long jump, the European Athletics Champion 2010; prize winner of the World Paralympic and Paralympic Games among athletes with visual impairments (T12 category) in 2016. T12 is a category of athletes - disabled people with visual impairment. All athletes with disabilities are classified according to the degree of visual impairment. The examined athlete acts in the category T12 in connection with visual impairment in combination with disorders of the retina of the eyes. However, in powerful lenses can run, work at a computer, etc.Psychophysiological testing of the athlete took place highly close to the computer screen.

The study was conducted for 5 months. Twice a week, testing was conducted (psychophysiological indicators and running speed). Thus, only 36 tests of one athlete were conducted.

*The course of the study*

Individual characteristics of the psychophysiological state and results in running for 100 m during the five months of 2015 were analyzed. The models of multiple linear regression between results in running at 100 m and psychophysiological indices are compiled.

The results in the 100 m race were recorded in official and unofficial competitions. A total of 36 results were analyzed. 1 day before the start, psychophysiological indicators were recorded using the computer program "Psychodiagnostics" [5, 8]. Reaction time tests were conducted using this computer program The following parameters were fixed:

- a complex of indicators for the speed of a simple visual-motor reaction: average of 30 attempts [ms], standard deviation, quantity quantity of errors, duration of exposure (signal) - 900 ms;
- a complex of indicators of a complex visual-motor reaction of selecting 1 element from three and selecting two elements from three: mean value of 30 attempts [ms], standard deviation, quantity of errors, duration of exposure (signal) - 900 ms;
- a complex of indicators of a visual-motor reaction of selecting two elements out of three in the feedback mode; as the response time changes, the signal delivery time changes; "Short version" is carried out in the feedback mode, when the duration of exposure changes automatically depending on the response of the subject: after the correct answer, the duration of the next signal is reduced by 20 ms, and after the wrong one - increases by the same value.

The range of the signal exposure change during the test subject's operation is within 20-900 ms with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button while displaying a certain exposure (image), or during a pause after the current exposure. In this test, the time to reach the minimum exposure of the signal and the time of the minimum exposure of the signal reflect the functional mobility of the nervous processes; the quantity of errors reflects the strength of the nervous processes (the lower these parameters, the higher the mobility and strength of the nervous system). The duration of the initial exposure is 900 ms; the amount of change in the duration of the signals with correct or erroneous responses is 20 ms; pause between the presentation of signals - 200 ms; the quantity of signals is 50. The indicators are fixed: the average value of the latent period [ms]; standard deviation value (SD); quantity of mistakes; time of test execution [s]; minimum exposure time [ms]; time of exposure to the minimum exposure [s] - a complex of indicators of a complex visual-motor reaction of selecting two elements out of three in the feedback mode, i.e. As the response time changes, the signal delivery time changes; "Long version" is carried out in the feedback mode, when the duration of exposure changes automatically depending on the response of the subject: after the correct answer, the duration of the next signal is reduced by 20 ms, and after the wrong one - increases by the same value. The range of the signal exposure change during the test subject's operation is within 20-900 ms with a pause between exposures of 200 ms. The correct answer is to press the left (right) mouse button while displaying a certain exposure (image), or during a pause after the current exposure. In this test, the time to reach the minimum exposure of the signal and the time of the minimum exposure of the signal reflect the functional mobility of the nervous processes; the quantity of errors reflects the strength of the nervous processes (the lower these parameters, the higher the mobility and strength of the nervous system). In addition, the total time of the test reflects a combination of strength and mobility of the nervous processes. The duration of the initial exposure is 900 ms; the amount of change in the duration of the signals with correct or erroneous responses is 20 ms; pause between the presentation of signals - 200 ms; the quantity of signals is 120. The indicators are fixed: the average value of the latent period, ms; standard deviation value, ms; quantity of mistakes; time of test execution, s; minimum exposure time, ms; time of exposure to the minimum exposure, s.

The indicators of mental working capacity were also determined according to the Schulte test. In this test, the subject needs in the 5x5 tables of 25 digits (from 1 to 25) arranged in random order, in order to mark the numbers from 1 to 25. After passing the first table, the second with a different order of digits immediately appears, and so on. In total, the subject passes 5 tables. Fixed the running time on each table of five (min.), The work efficiency as the arithmetic mean of the running time on five tables [min].

To determine the degree of influence of psychophysiological functions on the athletic result in the 100 m run, a multiple regression analysis was carried out in a step-by-step method. The dependent variable was the result of running 100 m. Independent variables were 39 indicators of the psychophysiological state according to the applied methods of investigation. With the step-by-step method of multiple regression, the analyzed variables are involved in the analysis in turn. The algorithm of multiple regression analysis, provided by the SPSS program, allows selecting the most significant variables at each step in terms of the degree of influence on the sporting result. As a result, only those multiple regression models that contain the most significant coefficients are selected. The remaining variables are placed by the program in the table "Excluded variables". In our study, we focus on the analysis of multiple regression models containing variables included by the program as variables of multiple regression models with reliably significant coefficients.

*Mathematical processing of results*

Based on the results in running at 100 m and psychophysiological indicators, a multiple regression analysis was performed by the type of the linear model in a step-by-step method using the SPSS 17 and EXCEL 2016 programs.

# RESULTS

In this study computing of the results end up in following steps, that's why each part of results leads to another. Judging by the values of the coefficients R, $R^2$ and biased $R^2$, all six models are reliable and describe with a high degree of accuracy the relationship between psychophysiological indices and the 100 m run time of an elite sportswoman with visual impairment (Table 1). Since in all six models the values of R, $R^2$ and shifted $R^2$ are close to 1, one can judge the high degree of influence of psychophysiological indicators on the results in running at 100 m in an elite sportswoman with visual impairment.

The high significance of all six regression models (Table 2) also attests to the high degree of influence of psychophysiological indices on the time of 100m run over by an elite athlete.

The step-by-step method of multiple regression analysis allows one to involve the analyzed indicators in the model in turn. In our study, in the first step, i.e. in the first model, one indicator was involved - the time of a simple visual-motor reaction [ms] (Table 3). In the second step (model 2), in addition to the time of a simple visual-motor reaction (SVMR [ms]); the time of minimum exposure of the signal in the feedback test at 120 signals (MSE_120 [ms]) was involved in the analysis. In the third step, the following parameters were involved in the third model as variables affecting the running time of a 100 m interval: the time of a simple visual-motor reaction [ms]; time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]); time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]). In the fourth step, in the fourth model, the time of a simple visual-motor reaction [ms] was the influencing variables, the average minimum exposure time for the minimum exposure of the signal in the feedback test at 120 signals (MSE_120

[ms]), the minimum signal exposure time in test with feedback at 30 signals (MSE_30 [ms]); the response time of selecting two signals from three (ChR [ms]). The fifth model is represented by variables: the time of a simple visual-motor reaction [ms], the time of the minimum exposure of the signal in the feedback test with 120 signals (MSE_120 [ms]), the time of the minimum exposure of the signal in the feedback test with 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min]). The sixth model is described by an equation involving variables: the time of a simple visual-motor reaction (the average value for one test) (SVMR [ms]); minimum signal exposure time in a feedback test with 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min]) (Table 3).

In addition to variables reflecting psycho-physiological indicators, each model contains a constant that reflects other factors that affect the 100m run time of an elite athlete, regardless of the analyzed parameters of the psychophysiological state (Table 3). Other factors affecting the running time of 100 m are also reflected in the dispersion of the otatoks (Table 2).

Table 1. Summary table of regression models of the influence of psychophysiological indices on the time of running a distance of 100 m by an elite athlete with visual impairment (the quantity of measurements is 36)

| Model | R | $R^2$ | Adjusted $R^2$ | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | 0.966a | 0.933 | 0.931 | 0.12 |
| 2 | 0.976b | 0.953 | 0.951 | 0.10 |
| 3 | 0.983c | 0.966 | 0.963 | 0.09 |
| 4 | 0.986d | 0.973 | 0.969 | 0.08 |
| 5 | 0.989e | 0.977 | 0.974 | 0.07 |
| 6 | 0.989f | 0.977 | 0.974 | 0.07 |

Notes:

a. Influencing variables: (constant), time of simple visual-motor reaction, average value for one test of 30 signals (SVMR [ms]);
b. Influencing variables: (constant), time of simple visual-motor reaction, average value for one test (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]);
c. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]); time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]);
d. Influencing variables: (constant), the time of a simple visual-motor reaction (the average time of minimum exposure for the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]), the time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]), the response time for selecting two signals from three (ChR [ms]);
e. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); minimum signal exposure time in a feedback test with 120 signals (MSE_120 [ms]), minimum signal exposure time in a feedback test with 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min]);
f. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min])

Table 2. Summary table of sources of variance and significance of regression models of the influence of psychophysiological indices on the time of running a distance of 100 m by an elite athlete with visual impairment (the quantity of measurements is 36)

| ANOVA (g) | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | p |
| 1 | Regression | 7.172 | 1 | 7.172 | 476.809 | 0.000a |
| | Residual | 0.511 | 34 | 0.015 | | |
| | Total | 7.683 | 35 | | | |
| 2 | Regression | 7.326 | 2 | 3.663 | 338.206 | 0.000b |
| | Residual | 0.357 | 33 | 0.011 | | |
| | Total | 7.683 | 35 | | | |
| 3 | Regression | 7.421 | 3 | 2.474 | 301.283 | 0.000c |
| | Residual | 0.263 | 32 | 0.008 | | |
| | Total | 7.683 | 35 | | | |
| 4 | Regression | 7.472 | 4 | 1.868 | 274.099 | 0.000d |
| | Residual | 0.211 | 31 | 0.007 | | |
| | Total | 7.683 | 35 | | | |
| 5 | Regression | 7.509 | 5 | 1.502 | 258.81 | 0.000e |
| | Residual | 0.174 | 30 | 0.006 | | |
| | Total | 7.683 | 35 | | | |
| 6 | Regression | 7.508 | 4 | 1.877 | 332.167 | 0.000f |
| | Residual | 0.175 | 31 | 0.006 | | |
| | Total | 7.683 | 35 | | | |

Notes:

a. Influencing variables: (constant), time of simple visual-motor reaction, average value for one test of 30 signals (SVMR [ms]);
b. Influencing variables: (constant), time of simple visual-motor reaction, average value for one test (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]);
c. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]); time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]);
d. Influencing variables: (constant), the time of a simple visual-motor reaction (the average time of minimum exposure for the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]), the time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]), the response time for selecting two signals from three (ChR [ms]);
e. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); minimum signal exposure time in a feedback test with 120 signals (MSE_120 [ms]), minimum signal exposure time in a feedback test with 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min]);
f. Influencing variables: (constant), time of simple visual-motor reaction (average value for one test) (SVMR [ms]); time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]); the response time for selecting two signals from three (ChR [ms]); the operating time on the third table in the Schulte test (ScT_3 [min])
g. The dependent variable is running of the distance of 100 m (Run_100 m) [s].

The analysis of the reliability of the multiple regression coefficients in the calculated models shows that in the first, second, fifth and sixth models, all the coefficients and the constant are reliable ($p<0.05$) (Table 3). In the third and fourth models of multiple regression, the constant is not reliable (Table 3). Judging by the values of the Beta value for regression coefficients, in all six models the most influential time for running 100 m is the parameter of a simple visual-motor reaction (SVMR [ms]). The second in terms of the degree of influence, albeit considerably less, is the time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]). However, in the fifth and sixth models, the magnitude of the influence of the operating time on the third table in the Schulte test (ScT_3 [min]) is practically the same as the magnitude of the effect of the simple visual motor reaction (Table 3).

Table 3. Coefficients of multiple regression equations with incremental involvement of indicators (the quantity of measurements - 36)

| Model | Coefficients with Variable Regression Equations | Unstandardized Coefficients | | Standardized Coefficients | t | p |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2.765 | 0.433 | | 6.388 | 0.000 |
| | SVMR [ms] | 0.04 | 0.002 | 0.966 | 21.836 | 0.000 |
| 2 | (Constant) | 1.824 | 0.444 | | 4.109 | 0.000 |
| | SVMR [ms] | 0.032 | 0.003 | 0.77 | 12.012 | 0.000 |
| | MSE_120 [ms] | 0.007 | 0.002 | 0.242 | 3.771 | 0.001 |
| 3 | (Constant) | -0.793 | 0.862 | | -0.92 | 0.365 |
| | SVMR [ms] | 0.033 | 0.002 | 0.815 | 14.208 | 0.000 |
| | MSE_120 [ms] | 0.006 | 0.002 | 0.2 | 3.503 | 0.001 |
| | MSE_30 [ms] | 0.006 | 0.002 | 0.114 | 3.396 | 0.002 |
| 4 | (Constant) | 1.521 | 1.152 | | 1.321 | 0.196 |
| | SVMR [ms] | 0.033 | 0.002 | 0.807 | 15.4 | 0.000 |
| | MSE_120 [ms] | 0.006 | 0.002 | 0.185 | 3.536 | 0.001 |
| | MSE_30 [ms] | 0.006 | 0.002 | 0.104 | 3.351 | 0.002 |
| | ChR [ms] | -0.004 | 0.002 | 0.086 | 2.748 | 0.01 |
| 5 | (Constant) | 5.808 | 1.999 | | 2.905 | 0.007 |
| | SVMR [ms] | 0.019 | 0.006 | 0.47 | 3.318 | 0.002 |
| | MSE_120 [ms] | 0.001 | 0.002 | 0.033 | 0.433 | 0.668 |
| | MSE_30 [ms] | 0.006 | 0.002 | 0.12 | 4.1 | 0.000 |
| | ChR [ms] | -0.006 | 0.002 | 0.118 | 3.749 | 0.001 |
| | ScT_3 [min] | 2.09 | 0.826 | 0.468 | 2.531 | 0.017 |
| 6 | (Constant) | 6.413 | 1.414 | | 4.535 | 0.000 |
| | SVMR [ms] | 0.018 | 0.005 | 0.436 | 3.759 | 0.001 |
| | MSE_30 [ms] | 0.007 | 0.001 | 0.124 | 4.48 | 0.000 |
| | ChR [ms] | -0.006 | 0.001 | 0.123 | 4.28 | 0.000 |
| | ScT_3 [min] | 2.369 | 0.511 | 0.53 | 4.633 | 0.000 |

Notes:
Constant is a constant,
SVMR [ms] - time of simple visual-motor reaction, average value for one test of 30 signals [ms];
MSE_120 [ms] - time of the minimum exposure of the signal in the test with feedback at 120 signals [ms];
MSE_30 [ms] - time of the minimum exposure of the signal in the test with feedback at 30 signals [ms];
ChR [ms] - the response time of the selection of 2 signals of three [ms];
ScT_3 [min] - time of work on the third table in the Shulte test (Shul_3) [min]

Based on the results of the analysis of the coefficients in the multiple regression models obtained, we chose the fifth model to describe the effect of psychophysiological functions on the 100m run time of an elite athlete with visual impairment, since it contains 5 indicators (the largest quantity of all the models obtained) with reliable coefficients and the presence of a 2-factor with Beta values greater than 0.4. As a result, the following regression equation was obtained:

$$y=5.808+0.019x_1+0.001x_2+0.006x_3-0.006x_4+2.09x_5 \quad (1)$$

where:
*y* - running time of an elite athlete with a visual impairment of the distance 100 m;
$x_1$ - time of simple visual-motor reaction SVMR [ms],
$x_2$ - the time of the minimum exposure of the signal in the test with feedback at 120 signals (MSE_120 [ms]),
$x_3$ - the time of the minimum exposure of the signal in the test with feedback at 30 signals (MSE_30 [ms]);
$x_4$ - the response time of the selection of 2 signals from three (ChR [ms]);
$x_5$ - working time on the third table in the Schulte test (ScT_3 [min]).

Substituting the average values of the results of psycho-physiological testing of the athlete (Table 4) in this equation, we obtain:
Run_100 m [s] = 5.808+0.019·238.08+0.001·383.31+0.006·434.22-0.006·435.81+2.09·0.52
Run_100 m [s] = 12.20

The relationship between running time 100 m and psychophysiological indicators is presented in Figures 1-3. For visual presentation, the psychophysiological indices of the first and second models were chosen, since they appear at the first steps of multivariate regression analysis. Graphical representation of these indicators indicates a high relationship between the running time of a distance of 100 m of the time of a simple visual-motor reaction (Figure 2), between the 100 m run time and the minimum signal exposure time in a feedback test with 120 signals (Figure 3), as well as between all three of these indicators (Figure 3).

Table 4. The results of repeated testing of an elite athlete (woman) with visual impairment

| Indicators | N | Minimum | Maximum | Averange | SD | m |
|---|---|---|---|---|---|---|
| Run_100 m [s] | 36 | 11.37 | 13.2 | 12.20 | 0.47 | 0.08 |
| MSE_120 [ms] | 36 | 345 | 400 | 383.31 | 15.21 | 2.53 |
| SVMR [ms] | 36 | 222 | 265 | 238.08 | 11.42 | 1.90 |
| MSE_30 [ms] | 36 | 420 | 452 | 434.22 | 8.71 | 1.45 |
| ChR [ms] | 36 | 420 | 452 | 435.81 | 9.70 | 1.62 |
| ScT_3 [min] | 36 | 0.35 | 0.69 | 0.52 | 0.10 | 0.02 |

Notes:
Run_100 m - running time of the distance 100 m [s];
SVMR is the time of a simple visual-motor reaction, the average value for one test of 30 signals [ms] (time of a simple visual-motor reaction);
MSE_120 - the time of the minimum exposure of the signal in the test with feedback at 120 signals [ms] (minimum signal exposure);
MSE_30 - the time of the minimum exposure of the signal in the test with feedback at 30 signals [ms] (minimum signal exposure);
ChR - the reaction time of the choice of two signals of three [ms] (choice reaction);
ScT_3 - time of work on the third table in the Schulte test (Shul_3) [min] (Schulte table);
N - quantity of tests

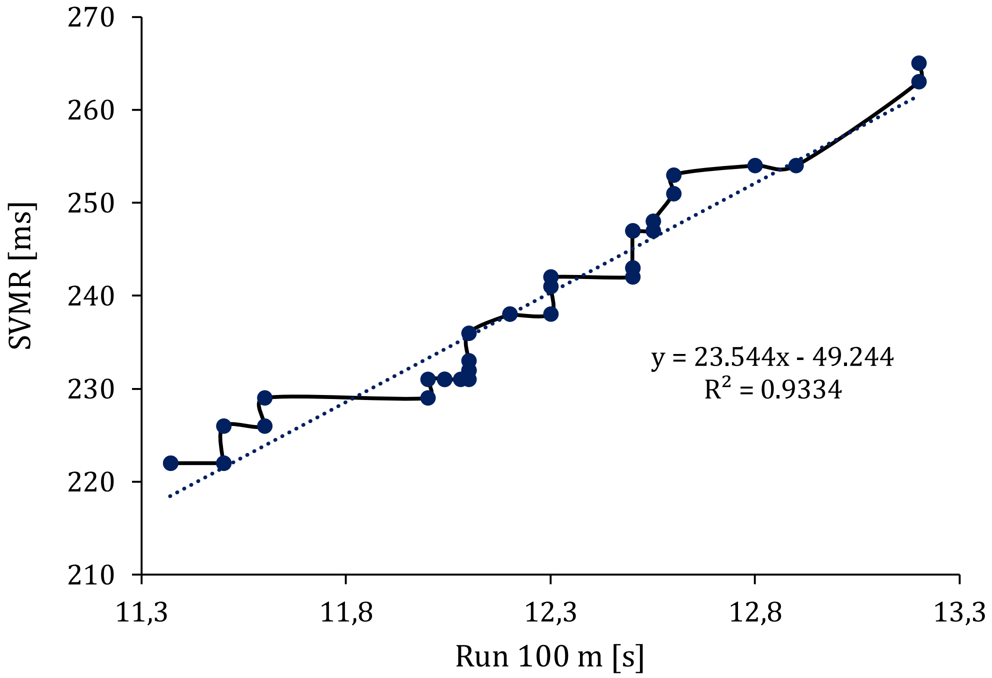


Figure 2. The relationship of running time 100 m and the time of a simple visual-motor reaction (source: drawing by authors): Run_100 m [s] - running time of the distance 100 m [s]; SVMR [ms] is the time of a simple visual-motor reaction, the average value for one test of 30 signals [ms].

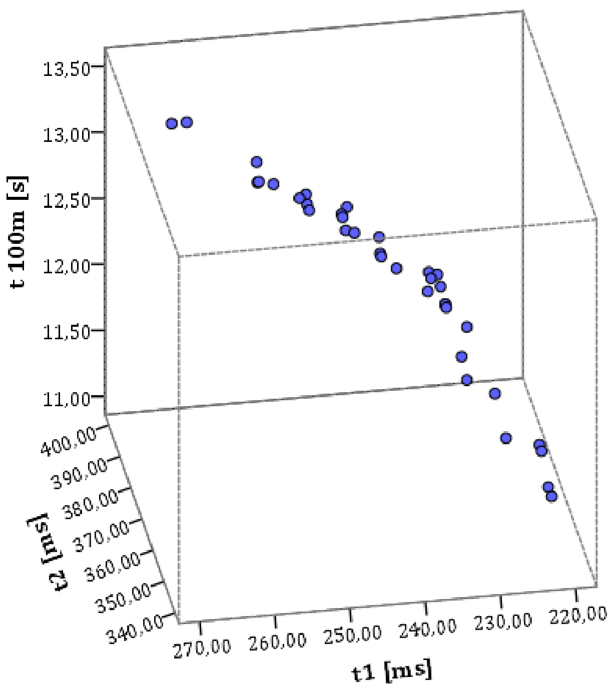


Figure 3. The relationship of running time 100 m, the time of a simple visual-motor reaction and the time of the minimum exposure of the signal in the test with feedback at 120 signals (source: drawing by the authors): t 100 m, s - the running time of the distance 100 m [s]; t1- time of simple visual-motor reaction, average value for one test of 30 signals [ms]; t2- time of the minimum exposure of the signal in the test with feedback at 120 signals [ms].

# DISCUSSION

The obtained results confirmed the hypothesis put forward in this study that elite sprinters have a high correlation between psychophysiological functions and running speed. The aim of the work was to theoretically and experimentally substantiate the influence of psychophysiological factors on individual performance in athletics sprint in high-qualified athletes on the example of an elite athlete. The obtained regression models with the involvement of 1 to 5 psychophysiological indicators indicate the presence of a high degree of influence of psychophysiological indicators on the result in a 100m run in an elite athlete. This is evidenced by high values (close to 1) of the R-square, as well as high reliability of the regression models obtained and individual coefficients of the regression equations.

In our case, the most significant effect is on the rate of a simple reaction. This is quite natural, since the speed of response to the signal is one of the most important factors as a result of running at 100 m. We investigated the time of a simple visual-motor reaction. The athlete underwent research in optical lenses, so the lack of visual function was leveled.

In this study, it was also suggested that there are psychophysiological factors that determine the athletic result individually for each athlete. This assumption was confirmed for the examined athlete. Psychophysiological indices were revealed that have a significant effect on its result in running at 100 m. Based on the data obtained, it can be concluded that for other elite athletes, sprinters, there are also indicators of psychophysiological functions affecting their running speed. It is possible that these indicators will be similar to those that we received when examining an elite athlete (woman). It is also possible that these indicators will vary somewhat among different athletes. This aspect requires additional research. In the literature [5,11,12] indicates that there is a psychophysiological complex of the sprinter, characterized by a high speed of simple reaction, weakness and mobility of the nervous system. This provision is confirmed by our research only partially. The speed indicator of a simple visual-motor reaction, which entered into all of the six regression models, really reflects the typical psycho-physiological complex of the sprinter. In addition, the time of the minimum exposure of the signal in the test for the rate of a complex reaction in the feedback mode at 30 signals reflects the mobility of the nervous system [5]. This indicator entered the fifth and sixth regression models. This fact also reflects the typical psycho-physiological complex of the sprinter.

However, as the most significant coefficients in model 2-6, the time index of the minimum exposure of the signal in the test for the rate of a complex reaction in the feedback mode at 120 signals also reflects not only the mobility of the nervous system, but also its ability to work for a long time [5]. The ability to work effectively for a long time (the strength of the nervous system) partially reflects also the exponent of working time on the third table in the Schulte test. He entered the fifth and sixth regression models. This fact contradicts the description of a typical psychophysiological complex of a sprinter [5,11,12], since it indicates the ability of the examined athlete to prolong the work of the nervous system, hence, the strength of her nervous system. This may be due to its individual characteristics, as well as the development of compensatory mechanisms associated with a lack of visual analyzer. The examined athlete is also characterized by a high ability to develop speed at a distance. This requires the efficiency and stability of the nervous system, which is reflected in the high importance of psychophysiological indicators characterizing these qualities [18,19]. The high efficiency of the nervous system, revealed in the examined athlete, can also be a compensatory mechanism for the failure of visual function. This confirms the second part of the hypothesis put forward that athletes with visual impairment increase the influence of psychophysiological factors as compensatory mechanisms of limited visual possibilities. This fact is also a partial experimental justification of the presented theoretical concept. The strength of nervous processes is an individual characteristic of the athlete under examination. According to our concept, the development of the athlete's strengths gives additional information to the central nervous system about the movement of the athlete, which will block the danger signal due to the lack of a visual analyzer, and the speed of the athlete's run will not decrease. Thus, a strong nervous system helps an elite sportswoman with visual impairment to show high sports results in a sprint.

It should also be noted that the indicator of a complex reaction of selecting two signals from three entered the fifth and sixth models with a small coefficient and a negative sign. The data obtained may indicate that to achieve the 100 m run time with a minimal time of the nervous system, it is necessary to focus on one task. The introduction of additional tasks adversely affects the performance in running on 100 m.

The obtained data supplement the results of studies by Ilyin [11,12], Lisogub [5], Korobeynikov [6] on the presence of psycho-physiological characteristics of representatives of various sports. However, these authors did not conduct research on athletes with disabilities. The results obtained in our study indicate that the athlete's sprinter with visual impairment developed the strength of the nervous system. This situation is different from previous studies on healthy athletes. In the studies it is shown that in healthy sprinters there is not a high development of the strength of the nervous system. Therefore, the findings in our study on the strength of the nervous system in an elite athlete with visual impairment are relatively new. For the first time, the influence of psychophysiological indices characterizing the working capacity (strength) of the nervous system on the result in running on 100 m is shown. For the first time theoretical positions on the mechanisms of speed limit limitation for athletes with visual impairments and possible ways of compensating their limited abilities in sprinting are formulated.

The results obtained make it possible to make the following recommendations for practical work. Since the surveyed athlete is characterized by pronounced mobility of the nervous system and a high speed of simple reaction, in the training process it is expedient to focus on the development of the starting speed and the ability to change the degree of tension and relaxation of the muscles. The examined sportswoman is also characterized by the expressed strength of the nervous system. Therefore, it also needs to concentrate on maintaining speed at a distance for the development of its strong quality, which also acts as a compensation for lack of sight. Development of strengths of the athlete provides additional information to the central nervous system about the movement of the athlete, as a result of which the danger signaling is blocked due to the lack of a visual analyzer, and the speed of the athlete's run does not decrease.

Further studies require verification of these provisions on other sprinters with visual impairments.

# CONCLUSIONS

1. A theoretical concept of the regulation of the running speed of the nervous system in athletes with visual impairment is developed. Athletes with visual impairment have more difficulties than healthy athletes in developing the maximum running speed because of the blockage of speed from the central nervous system. Partial or complete solution of this problem lies in the activation of compensatory mechanisms in the absence of visual function. With the development of psycho-physiological functions characteristic of a particular person, compensatory mechanisms develop to reduce the lack of a visual analyzer.
2. The models of multiple linear regression between the results in the 100m run for an elite athlete with visual impairment and psychophysiological indices are made. The selected model of multiple regression is represented by the following variables: the time of a simple visual-motor reaction [ms], the average time of the minimum exposure of the signal in the feedback test at 120 signals [ms], the time of the minimum exposure of the signal in the feedback test with 30 signals (ms ), the time of minimum exposure of the signal in the test with feedback at 30 signals [ms]; response time for selecting two signals from three [ms] (with a negative sign); the operating time on the third table in the Schulte test [min].
3. Compensatory mechanisms of insufficiency of the visual function to maintain high speed in the 100m run as psychophysiological functions are revealed: the indicators characteristic of sprinters (the speed of simple reaction and the mobility of the nervous system) and specific indicators (efficiency, strength of the nervous system).

**Conflict of interest.** The authors state that there is no conflict of interest.

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