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# Features of Functioning of the Central Nervous System of the Residents of Moscow and Moscow Region

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## Abstract

The study focuses on the lability and adaptability of the central nervous system of residents of Moscow and Moscow region aged 65 and older. All examinees regularly practised various types of physical activity, such as Nordic walking, cycling, Qigong gymnastics, etc. The functional state of the central nervous system of the examinees was studied using the Psychophysiologist hardware-software system by determining simple visual-motor reaction (SVMR), complex visual-motor reaction (CVMR), reaction to a moving object (RMO). Based on the analysis of speed and stability of sensorimotor reactions in response to light stimuli and moving object we made an express-evaluation of the level of functional state of the central nervous system, sensorimotor reactions, quality of activity, balance of inhibition and excitation processes. As a result of the study, the optimal level of CNS functioning was registered in most of the examinees. Activation of the central nervous system in the majority of the examinees is at an average level, the average level of operative efficiency is noted. The results of the study indicate a shift in the balance of nervous processes in the examinees towards inhibition.

**Keywords:** Human central nervous system functioning; Sensorimotor responses; Adaptive regulation; Cerebral homeostasis.

## 1. Introduction

The study of the functional state of the central nervous system, which is an important criterion of human health, is justifiably of great interest to specialists in physiology, medicine, hygiene, and physical education (Bartolomeo, 2021; Diamond and Ling, 2016; Fedorova, 2019; Frick and Möhring, 2016; Hülsdünker *et al.*, 2019; Kosachev, 2000; Maurer and Roebers, 2020;2021; Miyake *et al.*, 2000; Zimkina, 1978), etc and others. The problem of adaptation and lability of nervous processes of the residents of the metropolitan area and Moscow agglomeration attracts special attention, considering the changing trend of urbanization to suburbanization (Fedorova, 2019; Yolshina, 2015)

It is well known that electrophysiological methods of studying the functional state of the central nervous system, such as electroencephalography and rheoencephalography have long been actively used in scientific research and clinical medicine. At the same time, their use for mass examinations is difficult due to the high methodological complexity and high time costs of outfitting and registration procedures (Kosachev, 2000; Talalaev, 1992). For this kind of research, it is most suitable to use express methods, using psychophysiological techniques such as simple and complex sensorimotor reactions, reactions to a moving object, etc. (Kosachev, 2000; Park *et al.*, 2016; Zimkina, 1978). These methods are increasingly being used to assess the functional state of workers at their work places, the adaptation of trainees as well as athletes (Fedorova, 2019; Kosachev, 2000). At the same time, regulation of the functional state of the central nervous system in representatives of many social and age groups remains understudied. Thus, an express estimation of the level of functional capabilities of metropolitan city residents aged 65 and older who are regularly engaged in certain types of physical activity, including Nordic walking, cycling, Qigong practices, etc., is a very topical problem.

*Object of the study*: functional capacity of the human central nervous system.

*Subject of the research:* express estimation of functional state of the central nervous system of the residents of Moscow and Moscow region 65 years old and older.

*The objective of the study* is to estimate the level of psychophysiological capabilities of the residents of the metropolitan area and Moscow agglomeration aged 65 years old and older who are regularly engaged in some types of physical activity.

## 2. Material and Method

### 2.1. Participants

The work was conducted in strict accordance with the principles of research ethics outlined in the Declaration of Helsinki. In particular, each participant was informed of the purpose and procedure of the test and signed a voluntary informed agreement to participate in the study. All measures were taken to protect the privacy of the research participants and the confidentiality of their personal data.

The study design and procedure were clearly described and justified in the study protocol, which was sent for review and approval to the Ethics Committee of the Institute of Natural Science and Sport Technology of Moscow City Pedagogical University, before the work began. A total of 52 residents of Moscow and the Moscow region aged 65 and over took part in the study.

### 2.2. Devices

The functional state of the central nervous system of the examinee was studied using the Psychophysiologist hardware and software system. Psychophysiological techniques were used:

- Simple Visual Motor Reaction (VMR)

In response to light stimuli being presented, the examinee was asked to respond by pressing a button and the green colour indicator on the front panel of the device "Psychophysiologist" was lit up. The stimuli were presented sequentially, with 35 light pulses, of which the first 5 were training pulses and were not taken into account in the calculation. The time between stimuli was not fixed and varied according to a random law with a uniform distribution.

In this test the mean reaction time (MRT) as well as the standard deviation of reaction time (SDRT) were studied, and the level of central nervous system activation (R) was assessed.

- Complex visual-motor reaction (CVMR)

In response to the presented light stimuli, the green and red indicator on the front panel of the "Psychophysiologist" remote control, the examinee was required to press the corresponding button ("No" to the red light, "Yes" to the green one). The stimuli were presented in random order, in the number of 35 light pulses, the first five of which were not taken into account in the calculation and were training ones.

The mean reaction time (MRT) as well as the standard deviation of reaction time (SDRT) and the number of errors per stimulus were studied. The state of sensorimotor reactions (R), which determines the operative performance, was assessed.

- Reaction to a moving object (RMO)

The examinee was required to stop the rotating arrow by pressing the button as close as possible to one of the 12 LEDs located around the circumference and lit up randomly.

In these tests of sensorimotor reactions, the following parameters were studied: average time of deviation of real reactions from ideal reaction time, SDRT of deviation of reactions from ideal reaction time (IRT), balance coefficient, determining the ability to adequately perceive changes in spatial and temporal events (Kosachev, 2000; Liesefeld and Janczyk, 2019; Talalaev, 1992; Zimkina, 1978).

## 3. Results

The SVMR method makes it possible to perform a rapid assessment of the level of activation that characterizes the functional state of the central nervous system, based on the analysis of the speed and stability of sensorimotor reactions in response to light stimuli.

Adaptive regulation, which optimizes intra-central interactions and maintains adequate relations in the organism-environment system, determines responsiveness of sensorimotor reactions and is characterized by MRT.

Mechanisms of homeostatic regulation are aimed at stabilizing the adaptation level and retention of the formed functional system, without excessive fluctuations of its parameters. Stability of the regulatory mechanisms determines stability of sensorimotor reactions and is characterized by SDRT (Kosachev, 2000).

The level of activation of the CNS (R), the ratio of the MRT and the stability of the regulatory mechanisms, is an integral index of the functional state of the CNS (Kosachev, 2000).

The results of the SVMR study presented in Table 1 generally indicate average responsiveness and stability of the response. Activation of the central nervous system of the examinees is at an average level, which indicates a stable functional state of the regulatory mechanisms.

**Table-1**. Results of the SVMR study of residents of the capital and the Moscow agglomeration aged 65 and over who are regularly engaged in some form of physical activity

| № | Indicators | X ± m |
|---|---|---|
| 1. | Number of stimuli presented, pcs. | 30 |
| 2. | Mean reaction time (MRT), ms | 235,3 ± 4,3 |
| 3. | SD of reaction time (SDRT), ms | 56,4 ± 3,6 |
| 4. | Total number of errors (ER), pcs. | 0,86 ± 0,19 |
| 5. | CNS activation score (P), R.U. | 0,49 |

The CVMR method makes it possible to evaluate the level of sensorimotor reactions, which determines the level of operative efficiency, based on the analysis of reaction time and stability, as well as the number of errors on visual stimuli, characterizing the quality of the activity.

Results of the CVMR study, presented in Table 2, generally indicate an average level of performance and the quality of the test, which indicates an average level of operative efficiency of the examinees (Table 2).

**Table-2**. Results of the study of the CVMR of the residents of the metropolitan area and the Moscow agglomeration aged 65 and over who are regularly engaged in some form of physical activity

| № | Indicators | X ± m |
|---|---|---|
| 1. | Number of stimuli presented, pcs. | 30 |
| 2. | Mean reaction time (MRT), ms | 440,4 ± 8,1 |
| 3. | SD of reaction time (SDRT), ms | 98,5 ± 6,6 |
| 4. | Total number of errors (ER), pcs. | 1,76 ± 0,22 |
| 5. | Assessment of sensorimotor reactions (R), R.U. | 0,53 |

The RMO method makes it possible to study the peculiarities of CNS organisation in terms of accuracy and speed of reaction to a moving object, as well as to assess CNS equilibrium in terms of the degree of balance of inhibition and excitation processes.

Table 3 shows the results of the RMO study, which indicate low stability of the reaction and a shift of the balance of the nervous processes in the examinees towards inhibition. The average time of deviation of real reactions from the ideal reaction was 50.4 ms, while the standard deviation was ± 50 ms (Table 3).

**Table-3.** Results of an RMO survey of the residents of the metropolitan area and the Moscow agglomeration aged 65 and over who are regularly engaged in some form of physical activity

| № | Indicators | X ± m |
|---|---|---|
| 1. | Number of stimuli presented, pcs. | 30 |
| 2. | Average time of deviation of real reactions from ideal (ITR), ms | 50,4 ± 2,2 |
| 3. | SD of deviations of reactions from ITR, ms | 75,1 ± 3,5 |
| 4. | Balance coefficient | 1,4 |

# 4. Discussion

Analysis of the SVMR showed that of the 70% of the examinees with an average level of responsiveness, 45% had an average level of responsiveness, 10% had an above average level of responsiveness, and 10% had a high level of responsiveness. These examinees have an average level of CNS activation, which indicates their stable functional state. At the same time, 5% of the examinees showed low stability of reactions at an average level of activation. The recorded reduced level of CNS activation indicates an unstable functional state.

The average (2.5%) and below average (2.5%) levels of stability, predominance of inhibitory processes and reduced level of CNS activation were observed in 5% of 7.5% of the examinees with a below average level of speed. The 2.5% of the examinees with a below-average level of responsiveness showed below-average stability, predominance of inhibition processes, and a low level of CNS activation. The unstable state of the CNS of all the above examinees indicates a reduced level of functional capabilities.

Of the 10% of the participants with above-average level of fast response, 2.5% recorded below-average level of reaction stability, average level of CNS activation, which indicates a certain predominance of excitation processes and characterizes an average level of functional capabilities. Whereas 7.5% of the examinees had reaction stability and CNS activation level at average (5%) and above average (2.5%) values, excitation processes predominated, which indicates a high level of functional capabilities.

Reaction stability was below average for 7.5% of 12.5% of the examinees with high levels of quickness, while 2.5% had average and 2.5% had above average levels. The examinees in this category have a high level of CNS activation, excitation processes predominate, indicating a high level of CNS functional capabilities (Figure 1).

**Figure-1.** Distribution of examinees by level of performance and stability levels in the SVRM test (in % of the total number of examinees)
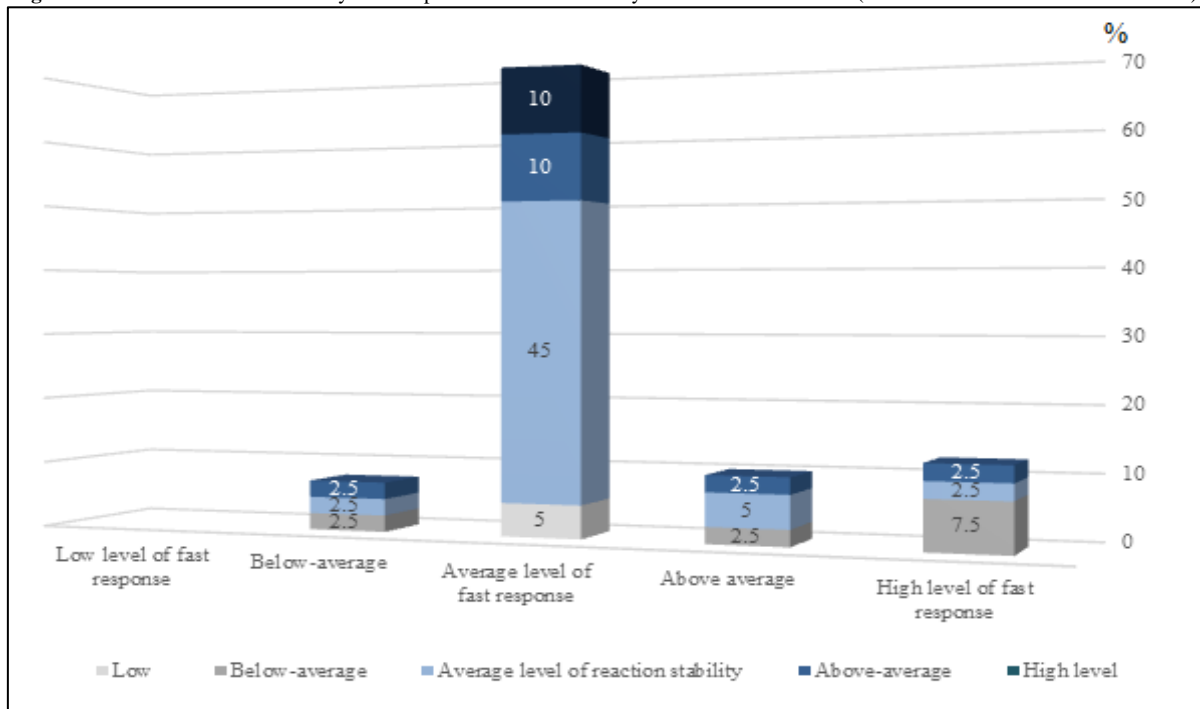


The SVMR study showed that 2.5% of the total participants had a low level of CNS activation, 10% had a below average level, 67.5% had an average level, 15% had an above average level and 5% had a high level (Figure 2).

**Figure-2.** Distribution of examinees according to the levels of CNS activation in the SVMR test (as a % of the total number of subjects)
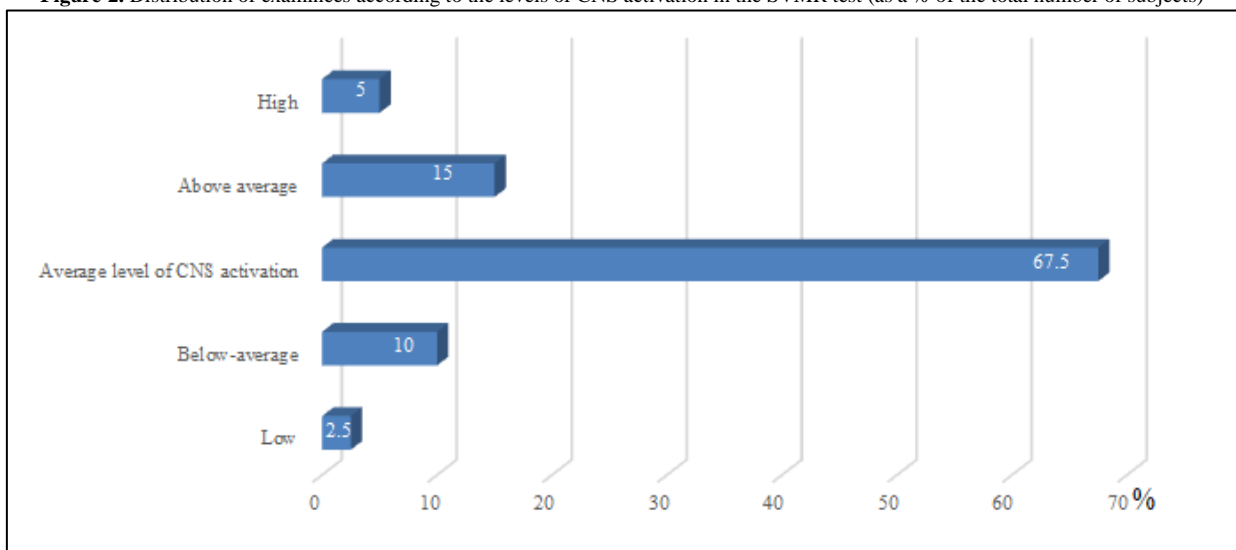


A more detailed analysis of the CVMR results showed that of the 43.2% of examinees with above-average performance level, 10.8% demonstrated a test quality level below average, indicating a decreased level of operative performance. At the same time, 13.5% of examinees with above-average responsiveness have an average level of performance, indicating an average level of operator performance. In turn, 10.8% and 8% of examinees with above-average responsiveness levels had above-average and high levels of test performance, respectively, indicating a high level of operational efficiency.

13.5% of 32.4% of examinees with an intermediate level of the speed of performance had an intermediate level of the quality of performance. Also, 8.1% of 32.4% of participants with an average level of speed have an activity quality level above the average and 8.1% have a high level of performance, indicating an emphasis on errorfree task performance to the detriment of reaction rate and indicating an average level of operator work capacity. In turn, 2.7% of examinees with an average level of performance had a test quality level below average, indicating an unfavourable state of the CNS for operator activity due to possible errors.

At the same time, 24.3% of the total were examinees with a high level of performance, of which 5.5% and 8.1% had a low and below-average level of performance, respectively; there was a marked emphasis on performance to the detriment of error-free actions, which indicated a reduced level of operator performance and the need for optimization of the CNS functional state. Among examinees with a high level of performance, 2.7% recorded an

average level of performance quality and the level of operative efficiency. At the same time, 5.4% and 2.7% had above average and high levels of performance quality, an optimal combination of error-free performance and high speed, respectively, indicating a high level of operator performance (Figure 3).

**Figure-3**. Distribution of examinees by level of performance and quality of performance in the CVMR test (in % of the total number of examinees)
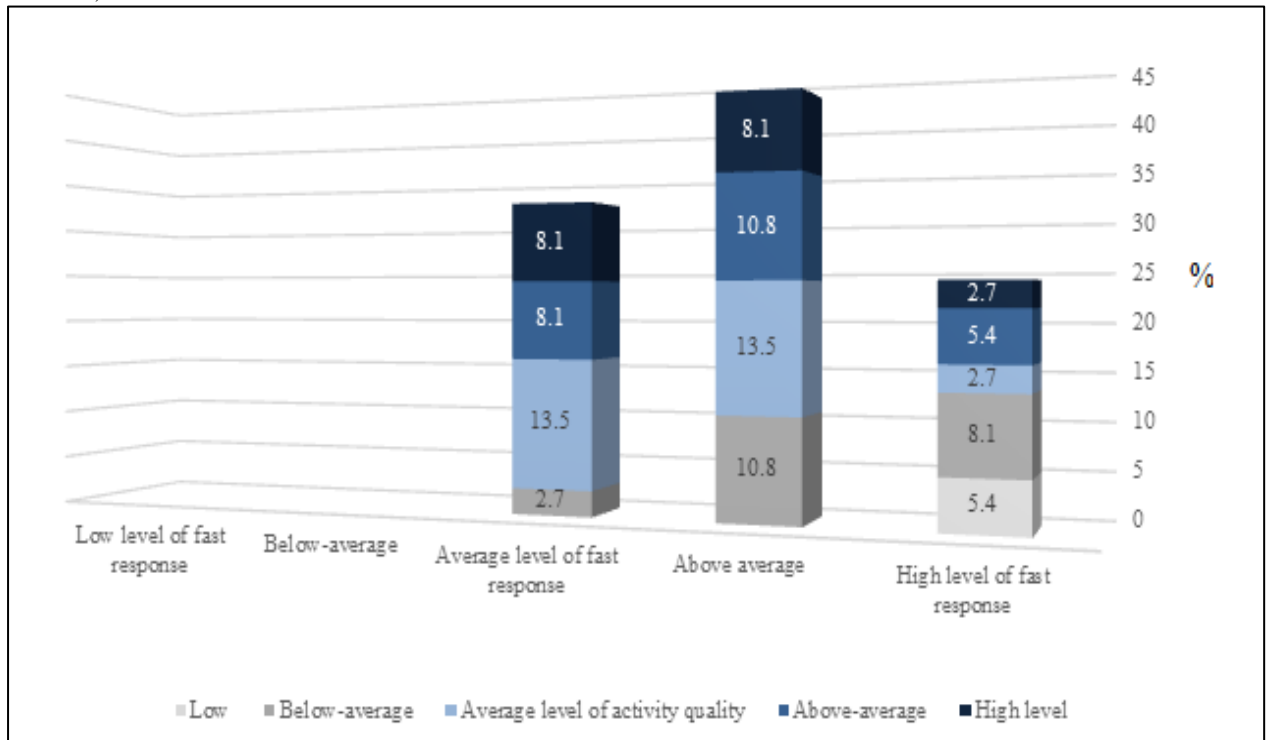


The CVMR study found that 5.5% of the total number of examinees had a low level of operator performance, 21.6% had a below average level, 45.9% had an average level, 18.9% had an above average level and 8.1% had a high level (Figure 4).

**Figure-4.** Distribution of examinees by level of operative performance in the CVMR test (in % of the total number of examinees)
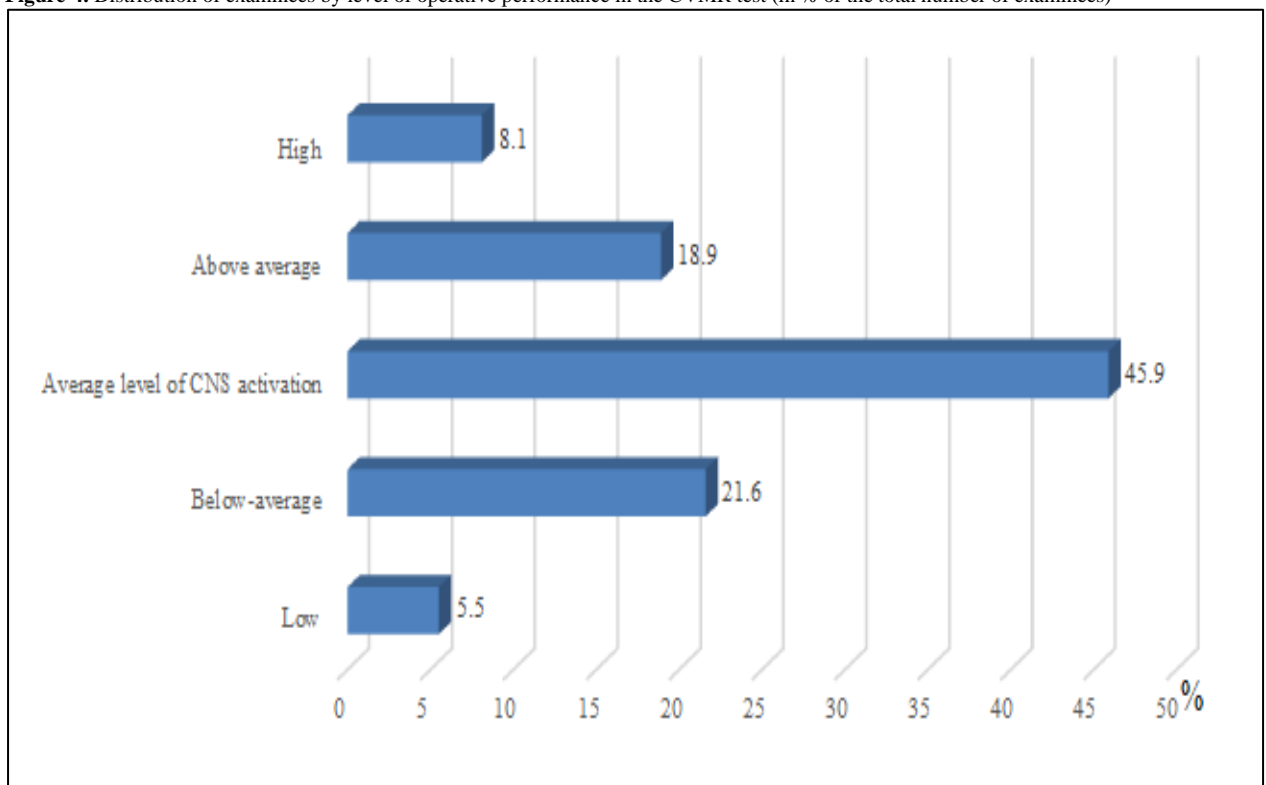


An analysis of the results of the RMO study showed that 75% of examinees had a predominance of inhibitory processes, 8.3% had a balance of nervous processes, and 16.7% had a shift of nervous processes towards excitation (figure 5).

**Figure-5.** Distribution of examinees by nerve balance bias in the RMO test (as a % of the total number of examinees)
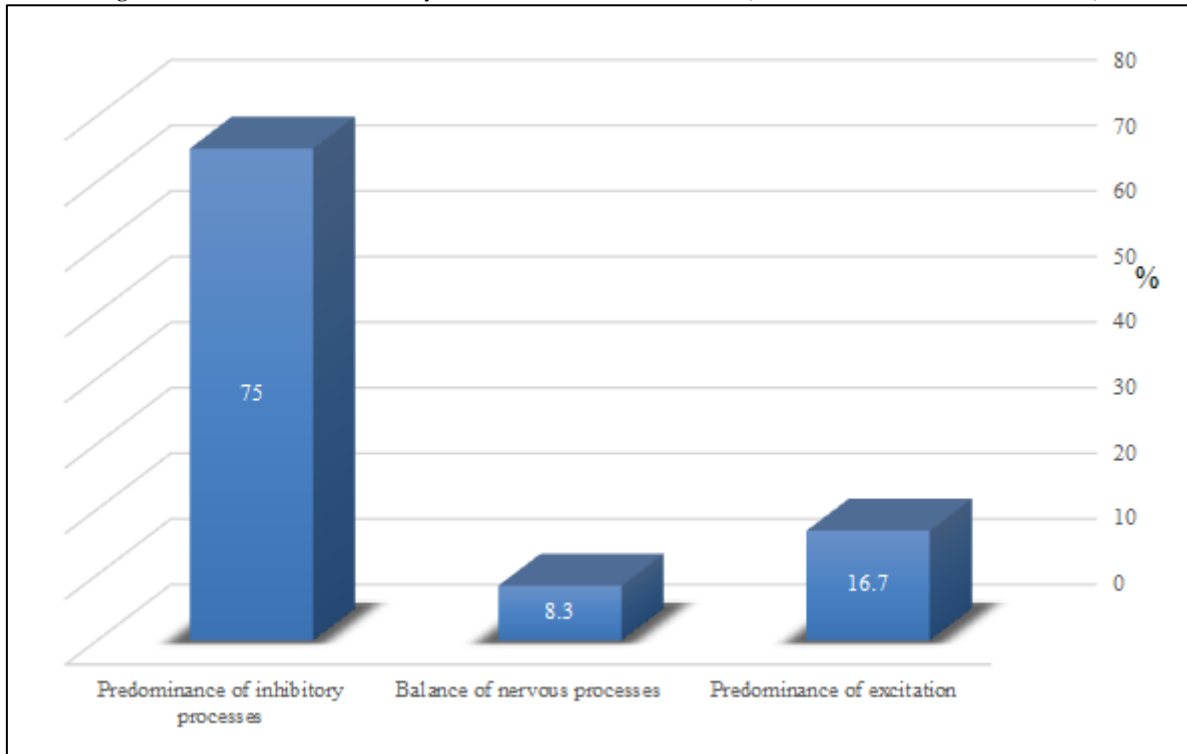


The level of stability was low in 78% and medium in 22.2% of the examinees. No high levels of stability were recorded in the examinees (Figure 6).

**Figure-6.** Distribution of examinees by level of response stability in the RMO test (in % of the total number of examinees)
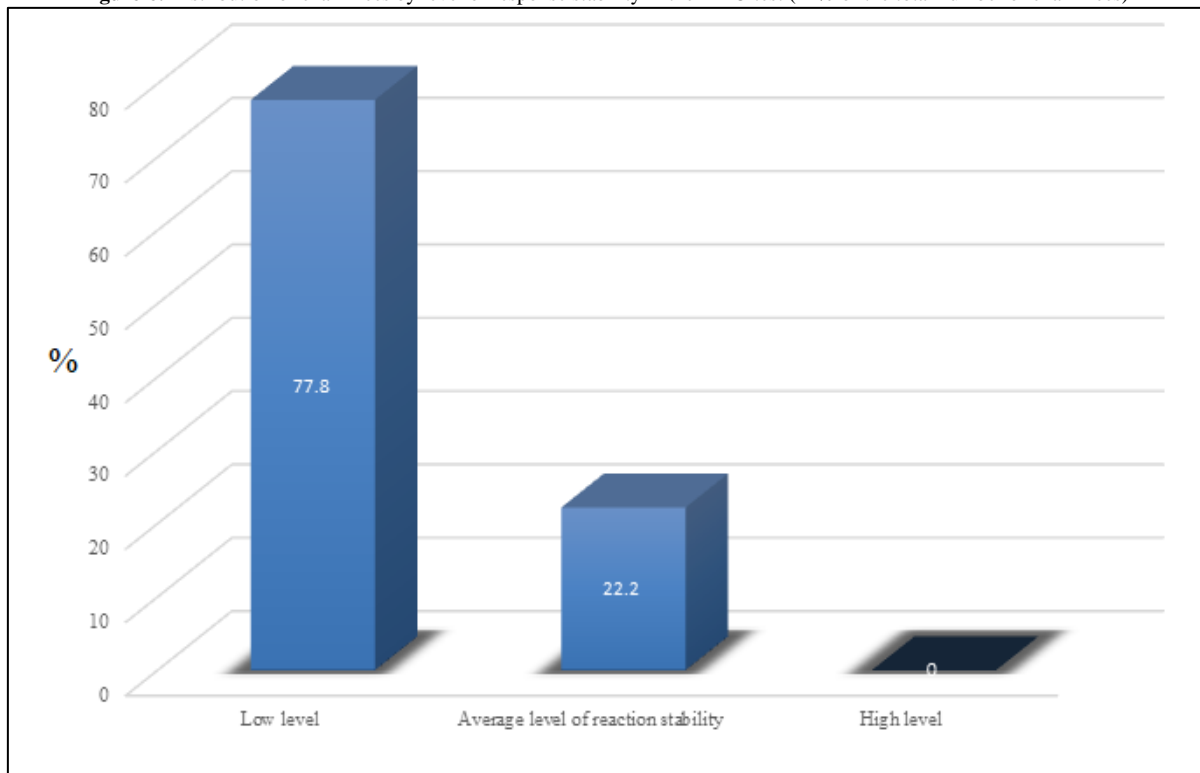


## 5. Conclusion

The SVMR study revealed that 67.5% of the total number of people surveyed in the metropolitan area and the Moscow metropolitan area aged 65 and over who regularly engage in some form of physical activity have an average level of CNS activation.

The RMO study showed that the majority of examinees (75%) have a shift in the balance of nervous processes towards inhibition, while 77.8% of the total number of examinees have a low level of stability of reactions.

As a result of CVMR investigation, 45.9% of the examinees were found to have an average, 18.9% and 8.1% above average and high level of the operative work capacity.

Thus, based on the analysis of the data obtained as a result of the SVMR, CVMR, RMO study, it can be stated that the majority of residents of the metropolitan area and Moscow agglomeration aged 65 and older who regularly engage in certain types of physical activity, including recreational Qigong, have the optimal level of CNS functional state.

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