Psychomotor reaction in adolescents with different levels of physical development

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Abstract. The work is aimed at studing dynamics of the latent time of motor reaction in conditions of noise interference in adolescents. The result of research of latent time of impellent reaction and force of nervous processes (under the tepping-test) at teenagers of 13-15 years with a certain level of physical development demonstrated that children with a high physical development level have low functional reserves brain programming systems. The influence of the processes underlying acceleration in terms of adaptive reactions of teenagers is showed by this way. The study of the motor reaction to a light stimulus was carried out using the latent time of simple motor reaction computer program developed in the laboratory. It was clear that the processes of acceleration affected the morph functional organization of regulatory brain systems, reducing their level of adaptability and operational reliability. Low indicators of adolescents' strength of nervous processes, which were obtained during tapping testing, are the general modern trend towards a decrease in the level of their health. The data obtained can be used in the development of medical and pedagogical methods for correcting the functional state of the body of adolescents at the prenosological stage.

1 Introduction

Children's health monitoring and surveillance is important in all aspects of their growth and development [1-12]. It is concerned with "the unique opportunity that each child has to achieve their full potential as a healthy adult" [11, p. 2]. The decline in the level of adolescents' health, that is expressed in an increase in morbidity, deceleration of development, deterioration of morphofunctional indicators, trophological insufficiency [2] determines the relevance of studying physiological means of negative processes in order to find effective preventive and screening methods for correcting functional disorders at the prenosological stage. "In addition to a child's physical well-being, there are also concerns about a child's behavior and emotional health" [11, p. 2].

The potential behavioral problems in children are of particular relevance. The adolescents are turned out to be the most sensitive group: the highest rates of growth in the number of diseases are observed among them [1]. "Recent studies have highlighted the acute effects of adolescents' psychomotor reaction, noting higher rates of depressive symptoms and declining in the level of their health" [3, p. 08008].

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Many studies of adolescents' psychophysiological status in psychomotor reactions determined that subjects were divided only by age and gender [4]. "Accumulated data on the adaptive reserves and various functional of children with different rates of physical development suggest differentiation of those works" [12, p. 80] according to its level, and primarily according to main indicator - length, with which all other morphofunctional parameters correlate [5]. Previously obtained data on differences in the mechanisms of energy supply, thermoregulation, adaptive reactions of children - accelerants, normodants and retardants [8-10] suggest the presence of specific patterns of regulatory brain mechanisms at the system level of the holistic organization of behavior, which is consistent with the concept of integrative brain activity. The method of motor response, which is traditionally applied in psychophysiological studies, provide identification of the characteristics of inhibition, lateral preferences, developing central fatigue and other brain neurodynamics correlates.

The work is aimed at studing dynamics of the latent time of motor reaction (LTMR) in conditions of noise interference in adolescents. We take into account that they have different rates of physical development - accelerators (A), having a high level, normodants (N) with an average level and retardants (R) with a low level.

2 Materials and methods

215 teenage students of 8th form from Sevastopol participated in given study. They were divided into three age groups (13, 14 and 15 years old).
The arithmetic value of body length (M) was determined by the formula 1:

$$M = \frac{1}{N} \cdot \sum_{i=1}^{N} P_i \tag{1}$$

where P_i– body length of the *i*-th subject, N is the number of subjects.
Standard deviation *(σ)* derived according to the formula 2:

$$\sigma = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^{N} (P_i - M)^2} \tag{2}$$

Their M±σ values were obtained. The respondents with body length within (M ± σ) were referred to normodants. Teenage students with a body length greater than (M + σ) were referred to accelerants, and less than (M – σ) – retardants (table 1).

The obtained data were processed by means of mathematical statistics methods. The significance of the differences was identified using Student's, Fisher's, and Cramer-Welch tests, the method of indirect differences.

Table 1. Growth standards

Age	Body length, centimetre	
	M	σ
13 years	163,61	±8,57
14 years	165,09	± 8,03
15 years	172,87	± 8,78

By means of the latent time of simple motor reaction (LTMR) computer program the study of the motor reaction to a light stimulus was carried out. The program was specially developed in our laboratory. The study was performed when working with the right, then the left hand in three experimental conditions.

I – registration of LTMR with an interstimulus interval of 2 seconds;

II – registration of LTMR with an initial interstimulus interval of 2 seconds and its increment of 200 ms with each subsequent presentation;

III – registration of LTMR with an interstimulus interval of 2 seconds under conditions of standard noise interference supplied through headphones.

The respondent was sitting in a comfortable position in front of the monitor screen, which was located at a distance of 60-80 cm from one's eyes. When a green square measuring 200 x 200 mm appeared on the screen, he pressed the "Enter" key as quickly as possible. At first all necessary parameters were established. 30 trials of the LTMR to the light stimulus were carried out in each group. Sigma deviations were additionally determined in 30 adolescents in each group in order to identify differences in the dispersion of LTMR.

The research of the strength and lability of the nervous system was carried out by means of the "TepTest" computer program, based on the method of conducting the tapping test by E.P. Ilyin [6].

The subject moved from square to square following a sound signal. It made the maximum number of strikes with a contact pen on each of the 6 squares of the metal plate within 5 seconds.

The testing time was 30 s, first with the right and then with the left hand. An automatically constructed graph of the dependence of the number of points placed on the square number and a tabular version of the results were analyzed and subjected to statistical processing.

The strength of the nervous system of adolescents was assessed: a strong nervous system was determined with a convex type of graph, medium strength with an even type, weak with a descending type, medium – weak with an intermediate and concave type [6].

3 Results and its discussion

The study showed that in the conditions with an interstimulus interval of 2s the reaction time averaged over all 30 tests in all groups did not differ significantly when working with the right hand (table 2).

Table 2. The LTMR value averaged over 30 samples in the studied groups in 1, 2, 3 experimental conditions.

	First experimental conditions, ms		Second experimental conditions, ms		Third experimental conditions, ms	
	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand
Accelerators	233 ±33	237 ± 30	245 ± 27	254 ± 33	255 ± 34	243 ± 28
Normodants	234 ± 42	227 ± 40	233 ± 40	236 ± 49	236 ± 47	228 ± 42
Retardants	230 ± 29	214 ± 34	227 ± 37	227 ± 34	235 ± 48	226 ± 35

Note: [1] – p<0.05 comparing with the onormodants' indicators, [2] – p<0.05 while comparing with the retardants' indicators.

The dynamics of LTMR from trial to trial in A, N and R were similar and in most trials the indicators did not differ significantly (Figure 1).

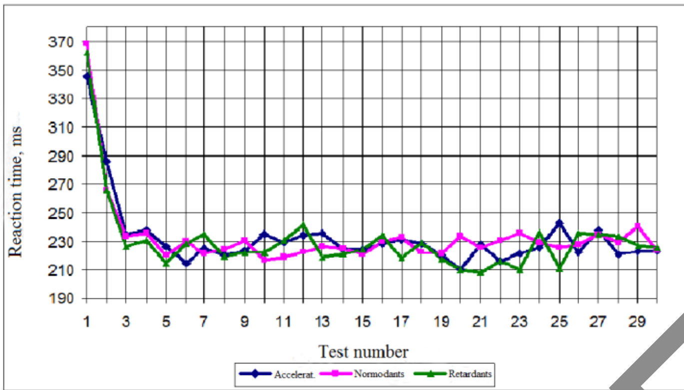


Fig. 1. Dynamics of LTMR in accelerators, normodants and retardants when working in the first experimental conditions with the right hand.

In all respondents, on trials 1–5, a period of burn-in was observed, characterized by high rates of LTMR (260–370 ms). When working with the left hand, P responded to the signal significantly faster than the right hand (p<0.05) and faster than A and H (table 2, figure 2).

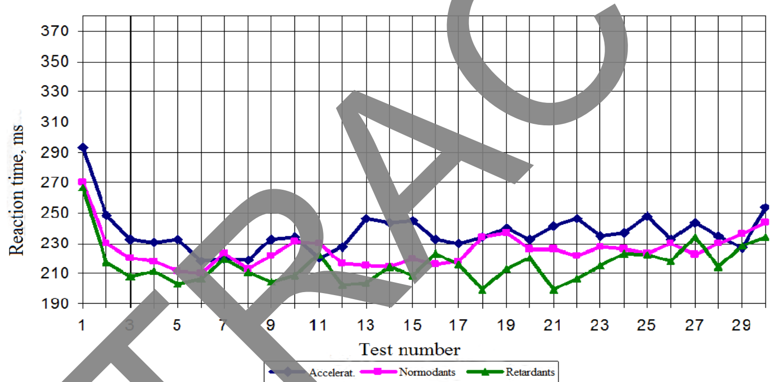
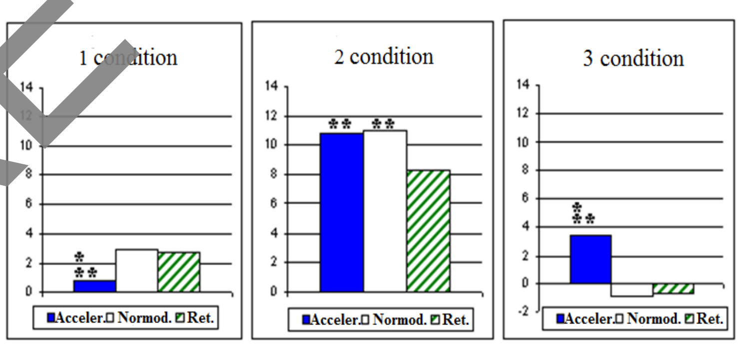
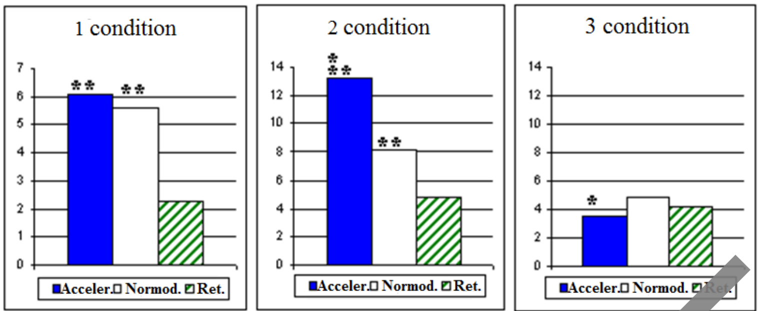


Fig. 2. Dynamics of LTMR in accelerants, normodants and retardants at working in the first experimental conditions with the left hand



A



B

Fig. 3. Fatigue progress (percentage increase in LTMR on the last 5 tests as compared with 6-10 tests for A, N and P during experimental conditions 1, 2)

A – testing with the right hand, B – testing with the left hand

Note: * – $p<0.05$ in contrast with the normodants' indicators, ** – $p<0.05$ as compared with the retardants' indicators.

The degree of fatigue (increase in LTMR in the last 5 tests compared to 6-10 tests, expressed as a percentage) was significantly ($p<0.05$) in A and N than in P.

In the second experimental conditions (with an increment of the interstimulus interval by 200 ms in each subsequent trial), the signal waiting time increased from 2 s in the second trial to 7.6 s in the 30th trial, which made it possible to assess the level of attention concentration in the studied groups.

When working with the right hand the LTMR averaged over all tests. For A it is higher ($p<0.05$), campared with P. The differences are not significant between A and H, H and P (table 2).

There was a gradual increase in LTMR from trial to trial After the run-in period (the first 5 ones). In A the degree of fatigue turned out to be significantly ($p<0.05$) higher than in N and R, the differences between which were not identified (figures 3, 4).

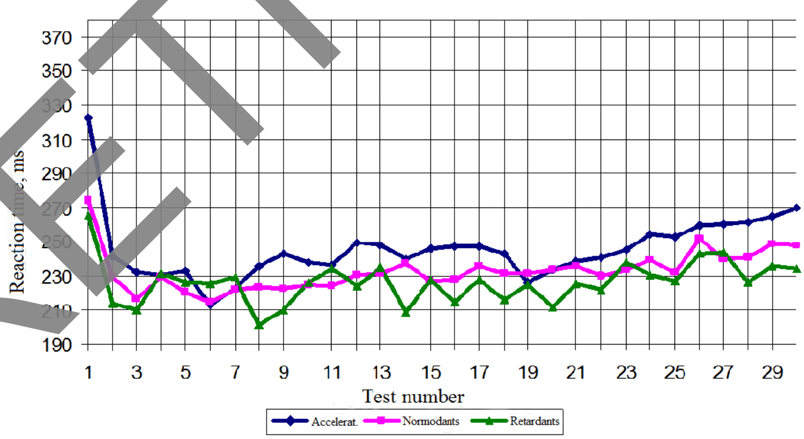


Fig. 4. Dynamics of LVDR in accelerators, normodants and retardants working with the right hand in the second experimental conditions

Similar situation of LTMR were observed when respondents were working with the left hand. LTMR increased by 13.28%, significantly ($p<0.05$) exceeding the indicators of N and P (figure 3).

In the third experimental conditions (testing with noise interference), the LTMR averaged over all tests turned out to be significantly ($p<0.05$) less for N and P than for A when working with both the right and left hands (table 2). Comparison of LTMR in the first and third experimental conditions allows to assess the level of noise immunity of adolescents: the smaller the increase in LTMR when working with interference (third experimental conditions) compared to LTMR indicators in the first experimental conditions, the higher the noise immunity. Noise immunity level (NIL), calculated by the formula 3:

$$\frac{1}{\mathrm{LTMR3}-\mathrm{LTMR1}}100\% \qquad (3)$$

where LTMR1 is the average reaction time for all samples in the first experimental conditions, expressed in arbitrary units (AU), LTMR3 is the average reaction time in the third experimental conditions.

UP turned out to be maximum in normodants (50 units), average in retardants (20 units) and minimal in accelerants (4.8 units).

Analysis of LTMR value showed that the reaction time of A is significantly ($p<0.05$) greater than that of H and P when working with the right and left hands, the differences between which are not significant (figure 5).

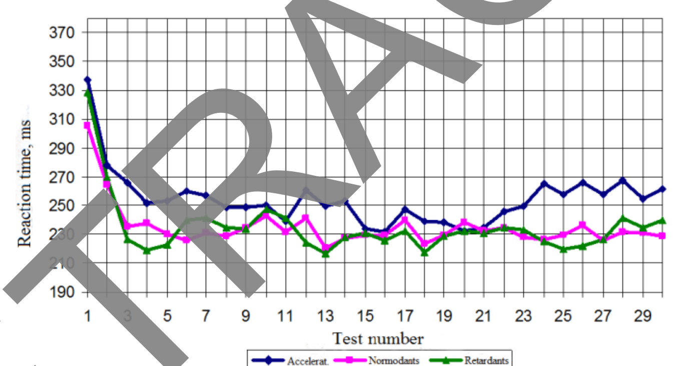


Fig. 5. LTMR dynamics in accelerants, normodants and retardants when working in the third experimental conditions with the right hand.

When testing with the right and left hands, N and P showed a stable response to the stimulus, while A responded significantly ($p<0.05$) worse at the end of testing than at the beginning (figure 3.5). No significant differences between N and P were found in most samples.

The study of the dispersion of LTMR indicators in A N and P using equal random samples (30 people in each group) showed that the most “stable” over time (in terms of the level of dispersion) are the indicators N, which in most experimental conditions are significantly different from A and P towards a decrease in scatter (table 3).

Table 3. The value of LTMR dispersion for A, N and P under different experimental conditions

	1st experiment conditions		2nd experiment conditions		3rd experiment conditions	
	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand
Accelerators	26	15	18	16	21	16
Normodants	27	12	12	13	14	10
Retardants	27	14	15	17	22	11

Note: [1] – $p<0.05$ when compared with normative indicators.

The high dispersion of LTMR in all groups in 1 experimental conditions when working with the right hand reflects the adaptation processes to the experimental conditions.

It was showed by means of Ilyin's method that accelerators have a descending type of performance graph when performing a test with the right hand.

This reaction indicates a weak type of nervous system. retardants and normodants have a concave type of performance graph. It presents a medium-weak type of nervous system (figure 6).

Accelerants and retardants had an intermediate type of performance graph, which indicates a medium-weak type of nervous system.

When performing the test with the left hand normodants had a descending type of performance graph. It shows a weak type of nervous system (figure 6).

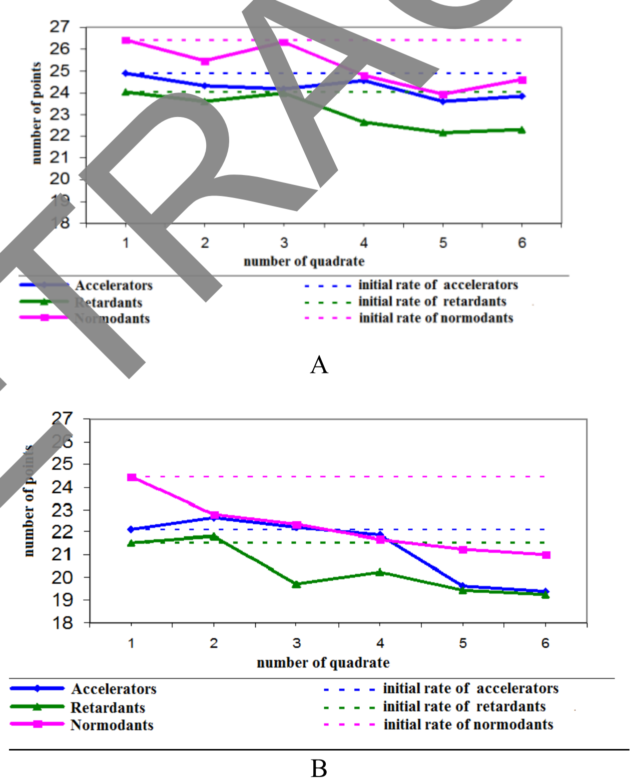


Fig. 6. Average graph of nervous system performance in respondents (results of the tapping test: A) - testing with the right hand; B - testing with the left hand.

Normodants demonstrated greater lability of nervous processes - the total number of points placed in 6 squares when working with the right hand was significantly ($p<0.05$) higher for them than for A and P (figure 6A, table 4).

Table 4. Number of points in 6 squares during the tapping test

	Total number of points (right hand)	Total number of points (left hand)
Accelerators	145,39 ±2,78 [1]	127,83 ±8,52
Normodants	151,50 ±5,95 [2]	133,56 ±7,63
Retardants	138,77 ±5,10 [1]	122,00 ±6,61 [1]

Note: [1] – $p<0.05$ when compared with the indicators of normodants, [2] – $p<0.05$ when compared with the indicators of retardants.

When testing with the left hand, the operating speed of N and A did not differ significantly, but was higher than that of R.

Thus, significant differences have been seen in the psychophysiological status of adolescents aged 13–15 years.

The most stable reactions were in normodants. They demonstrated a high stability of the response (in terms of the level of dispersion).

Low stability of accelerator responses is an early criterion for changes in the functional state of the central nervous system. Changing the type of psychomotor task caused tension in brain's programming systems. It was reflected in an increase in LTMR.

4 Conclusion

It is clear that in adolescents with a high level of physical development adaptive psychophysiological reserves are minimal. It presents peculiarities of the functioning of flexible parts of motor programming. They show the degree of adaptability of the individual.

The processes of acceleration affects the morphofunctional structure of regulatory brain systems. It reduces their level of adaptability and operational reliability.

Low indicators of the strength of nervous processes in accelerators are general trend towards a decrease in the level of children's health.

The data obtained can be used in the development of medical methods as well as pedagogical ones for correcting adolescents' functional state of the body.

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