CLINICAL STUDY

Physical development and psychical function states in junior schoolchildren

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Abstract

The authors studied the physical development level and condition of physical and neurodynamic functions in junior schoolchildren. The 55 girsl and 53 boys of the fourth form of a secondary school of nine-year age were examined. To evaluate the children's physical development, the authors measured the subjects' anthropometric and functional indices. Their results show that the physical development level correlates with the condition of psychical and neurodynamic functions. The physical development is inseparable from the formation of the psychophysiological functions in junior schoolchildren with learning. ***(Tab. 6, Ref. 16.)***

Key words: physical development, psychical functions, junior schoolchildren, neurodynamic functions, learning.

The development of modern school is characterized by difficulties of learning programs. The following school disciplines are in relation with informative technologies. However, this dynamics of difficult increases of school education sometimes fails to allow for the features of children's psychophysiological development. Due to the irrational increase in the volume of educational information, children demonstrate enhanced fatigue and impaired vision, reactions, and other psychophysiological functions of the body. There are many studies (Makarenko et al, 1997; Bogutska, 1997) dealing with the physical development and formation of psychical functions in children. However, studies describing the development of psychical functions parallel with physical development are absent.

Thus, our goal was to study the physical development level and formation of psychical functions in junior schoolchildren.

Methods

The 55 girls and 53 boys, schoolchildren of the secondary school aging 9 were examined.

The condition of psychical and neurodynamic functions in the schoolchildren were comprehensively examined three times: at the beginning (the first quarter), in the middle (the second quarter), and at the end (the fourth quarter) of the school year.

The three parts of experimental methods to evaluate the condition of psychical and neurodynamic functions were developed.

The first part evaluated the condition of the cognitive psychical functions using the computer-aided method developed (Kozak and Elizarov, 1995). Its main task is to characterize sensory-motor reactions, perception, attention, memory, and thinking.

The sensory-motor reactions were studied by two methods: the visual (the latent period of visual-motor reactions, LPVMR, s) and the acoustic (the latent period of audio-motor reaction, LPAMR, s).

The perception functions were studied by two methods: the evaluation of time perception using the modified "individual minute" test (Halberg et al, 1978) (time perception error, TPE, s) and the evaluation of space perception (space perception error, SPE, sm).

The perception functions were evaluated by comparison of real meanings of time or space segment with physical measures.

The voluntary attention volume (VAV, %) was measured by a proofreading test.

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The subjects were requested to perform a proofreading test, the task was to sign the "K" letter by the "1" figure and the "N" letter by the "2" figure. The attention volume was calculated from the ratio of the number of correct signed letters to the total number of letters presented in table to a subject.

The study of the memory functions was relied on two methods: the measurement of the short-term memory volume (STMV, %) from the share of corerctly memorized and repeated numbers form among ten two-digit numbers presented to a subject on a display within 30 s, and the measurment of the recent memory volume (RMV, %) using a test for counting the one-digit symbols memorized and correctly repeated by a subject after receiving verbal information in the inverse order (Wechsler, 1958).

A battery of five subtests was applied to characterize the thinking functions. They reflected abstract (m1), associative (m2), logic (m3), operational (m4), and spatial (m5) thinking.

Subtest 1 (abstract thinking)

The five words, which person can form around general abstract concept are presented on the computer's monitor randomly. Subtest includes the ten tasks.

For example: *a) peach, b) apricot, c) plum, d) cherry, e) apple.*

The words a, b, c, d are united as fruits which include bones. The apple has not bone. The odd word is apple. To answer person must sign the *apple* as an odd word, and press the computer's key "Enter".

Subtest 2 (associative thinking)

The subjects have to found the meaning link between pair words that are presented on the display. Subtest includes the ten tasks.

For example: *currant: berries, potatoes: ...? a) leaves, b) root, c) flowers, d) tubers, e) trunk.*

The currant associates with berries as potatoes with tubers. To answer person can sign the *d* word and press the computer's key "Enter".

Subtest 3 (logic thinking)

The subjects were requested to find of the minimal digit in the following ten double figures. Subtest includes the ten tasks.

For example: *12 34 56 89 65 34 19 46 29 67.*

The result of this task consist of digit "12" which is minimal among figures. To answer the person must press the computer's key "12".

Subtest 4 (operational thinking)

This subtest includes ten arithmetical tasks which person must correct.

Subtest 5 (spatial thinking)

Three tasks with absent figure are presented on the computer's monitor randomly. The subjects were requested to find of the figure which corresponding to both of the figures way.

The purpose of the second part of experimental methods was to measure higher nervous activity indices: the functional lability of nervous processes (FLNP), strength of nervous processes (SNP) and brain capacity (BC), using the computer-aided system (Chaichenko and Tomilina, 1995).

The nervous system strength coefficient was calculated as ratio of mean values of latent periods of a sensory-motor reaction to the first and last 20 signals from among 100 visual signals (a square on the display) presented in random intervals. The functional lability of the nervous processes of the brain was evaluated with the value of the minimum exposure to visual signals with which the number of erroneous reactions did not exceed 5 % in a series of 20 sensory-motor choice reactions (Makarenko, 1991). The brain capacity from the mean value of signal exposure on the display during testing that stabilized the error was value. The BC index was calculated from the ratio of the number of correct reactions to the total number of visual signals presented to a subject (Kozak et al, 2001):

$$BC = (Nr/Ng) \times 10,$$

where: *Nr* — number of correct reactions, *Ng* — total number of visual signals, *10* — correction factor.

The third part of experimental methods measured the level of the children's physical development subject (Kozak et al, 2001).

Table 1 shows the mean due values of the indices in junior schoolchildren obtained on the basis of our results and from published works (Tikhvinskii, 1985; Tikhvinksii and Khrushchev, 1991; Balsevich and Zaporozhanov, 1987; Volkov, 1984; Lukyanova et al, 2000).

Tab. 1. Due values of physical development indices in junior schoolchildren.

Parameters	Children	Age groups				
		8	9	10	11	12
Body length, sm	Boys	131.12±5.32	133.21±1.12	139.43±4.63	140.33±3.92	145.82±2.91
	Girls	126.25±6.13	129.42±1.56	132.92±4.51	136.72±0.91	139.41±1.21
Body mass, kg	Boys	27.81±3.01	28.88±0.81	29.42±2.91	32.61±4.12	36.31±2.52
	Girls	25.82±0.32	25.94±1.01	27.41±2.61	30.14±5.12	33.33±2.61
HR at rest, min^{-1}	Boys	94.63±0.81	93.01±2.00	89.34±2.14	87.38±1.58	84.83±1.48
	Girls	98.28±2.58	104.67±2.54	94.68±1.47	92.85±1.38	89.70±1.47
HR after exercise, min^{-1}	Boys	130.72±3.48	124.32±2.89	116.63±3.42	118.42±1.13	119.53±2.42
	Girls	139.52±3.45	138.95±2.32	124.43±2.85	120.17±1.89	118.76±1.78
Breath-holding at inhalation, s	Boys	37.80±2.33	38.46±4.56	53.61±5.32	58.31±1.13	61.01±5.64
	Girls	31.82±2.02	32.25±3.42	38.67±3.41	45.72±3.31	56.52±4.03
Breath-holding at expiration, s	Boys	16.60±1.91	17.00±1.47	17.00±1.47	20.04±1.51	22.51±4.14
	Girls	15.21±3.83	15.81±1.56	16.21±0.96	19.00±1.11	21.61±1.94
Back muscle strength, kg	Boys	-	45.93±2.54	53.44±2.12	68.92±2.21	98.13±2.54
	Girls	-	36.95±2.26	46.43±2.82	62.43±2.92	89.75±2.33
Vital capacity of lung, l	Boys	1.56±0.61	1.74±0.07	1.78±0.58	2.07±0.65	2.15±0.95
	Girls	1.34±0.81	1.45±0.1	1.55±0.78	1.79±0.81	1.87±0.97

Tab. 2. Classification of physical development index in junior schoolchildren.

Physical development level	Physical development index	
	Boys	Girls
High	≥1.180	≥1.140
Average	0.870-1.179	0.840-1.139
Low	≤0.869	≤0.839

Tab. 3. Percentage of physical development index among junior schoolchildren.

Physical development level	Physical development index	
	Boys (n = 53)	Girls (n = 55)
High	14%	17%
Average	36%	50%
Low	50%	33%

Tab. 4. Physical development indices in the examined junior schoolchildren.

Parameters	Girls (n = 55)	Boys (n = 53)
Body length, sm	140.54±1.02	139.92±0.98
Body mass, kg	32.51±0.82	32.96±0.74
HR at rest, min^{-1}	90.62±2.18	92.31±2.68
HR after exercise, min^{-1}	133.91±2.65	132.39±2.88
Breath-holding at inhalation, s	32.93±1.61	33.73±1.44
Breath-holding at expiration, s	22.40±1.46	20.96±1.49
Back muscle strength, kg	36.76±1.42	46.37±1.29*
Vital capacity of lung, l	1.7436±0.04	2.43±0.47

*- $p < 0,05$ compared to the girls.

The PDI (physical development indicis) value shows the physical development level, which may be high, average, or low. We developed a PDI classification for schoolchildren (Tab. 2).

Analyzing the physical development level of our subjects, we used the due values of the indices for the age of nine and ten years (Tab. 1).

Results

Analysis of the physical development level in junior schoolchildren is presented in Table 3. It shows that high PDI values were found only in 17 % of the girls and 14 % of the boys. This level was average in 50 % of the girls and 36 % of the boys and low in 33 % and 50 %, respectively. These data agree with the reports (Tikhvinskii, 1985; Baranov, 1999; Yampolskaya, 1999) about the deceleration of children's physical development in the early 1980s.

Tab. 5. Indices of psychical and neurodynamic functions at the beginning (I), in the middle (II), and at the end (III) of the school year in girls.

Parameters	I	II	III
Time perception error, s	2.95±0.02	7.28±0.02*	3.80±0.02***
Latent period of visual-motor reaction, s	0.34±0.02	0.32±0.03	0.30±0.01
Latent period of audio-motor reaction, s	0.27±0.02	0.27±0.05	0.25±0.01
Voluntary attention volume, %	89.38±1.91	97.15±2.61*	90.78±1.01
Short-term memory volume, %	54.16±2.87	56.66±5.56	47.27±5.06***
Recent memory volume, %	57.14±3.45	65.42±2.12*	65.01±1.74**
Abstract thinking index, %	57.51±3.91	50.83±9.00	68.18±2.63***
Associative thinking index, %	46.66±2.84	55.00±1.67*	37.27±3.04***
Logic thinking index, %	87.51±4.94	92.52±7.53	97.27±1.94**
Operational thinking index, %	86.66±4.14	93.33±6.51	96.36±2.03**
Spatial thinking index, %	66.66±8.24	77.91±2.68*	85.01±5.19***
Strength of nervous processes, secret unit	0.94±0.03	0.93±0.11	0.96±0.03
Functional lability of nervous processes, ms	751.66±69.41	691.12±93.96	690.72±92.50
Brain capacity, secret unit	16.75±3.60	19.91±2.75	16.63±5.01

* - $p < 0.05$ compared to the previous examination;

** - $p < 0.05$ compared to the first examination.

The physical development indices of our subjects are given in Table 4.

These data shows that our sample is characterized by significantly higher breath-holding (BH) values (both in the boys and in the girls, $p<0.5$) than the due values (Tab. 1).

The heart rate (HR) values both at rest and after exercises significantly exceed the due values in the boys, whereas the girls' breath-holding at inhalation (Bhinh) is significantly below the due values (Tab. 4).

This demonstrates reduced functional capacities of the children's cardiorespiratory system. Enhanced HR values after 20 squattings both in the girls and in the boys (Tab. 4) in comparison with the due values (Tab. 1) are caused by an impaired reaction of the cardiovaascular system to an exercise as a result of the decelerated development of the autonomic physiological systems in comparison with the somatic systems.

Table 5 lists the mean values of indices of psychical and neurodynamic functions in the girls at the beginning, in the middle, and at the end of the school year.

It is clear from the table that the second examination revealed a

Tab. 6. Indices of psychical and neurodynamic functions at the beginning (I), in the middle (II), and at the end (III) of the school year in boys.

Parameters	I	II	III
Time perception error, s	1.45±0.02	2.98±0.02*	0.42±0.001***
Latent period of visual-motor reaction, s	0.31±0.01	0.29±0.01	0.26±0.01**
Latent period of audio-motor reaction, s	0.26±0.02	0.21±0.01	0.22±0.01**
Voluntary attention volume, %	95.15±1.10	96.35±0.88	93.12±1.11
Short-term memory volume, %	38.46±2.96	40.13±5.54	40.12±3.48
Recent memory volume, %	59.28±1.19	66.71±2.31*	69.12±1.16***
Abstract thinking index, %	60.77±3.99	61.67±2.41	70.12±2.46***
Associative thinking index, %	53.07±2.86	55.83±1.92	45.12±3.79***
Logic thinking index, %	93.07±1.74	95.15±2.31	98.33±1.12***
Operational thinking index, %	79.23±3.66	83.33±7.62	93.33±2.56***
Spatial thinking index, %	77.12±8.75	69.51±7.67	89.11±4.69***
Strength of nervous processes, secret unit	0.94±0.03	0.92±0.04	0.87±0.03
Functional lability of nervous processes, ms	859.07±97.16	824.33±96.38	1192.33±63.24***
Brain capacity, secret unit	17.23±3.24	16.11±2.01	28.83±7.36***

* - $p < 0.05$ compared to the previous examination;

** - $p < 0.05$ compared to the first examination.

significant increase in VAV, RMV, m2 (associative thinking index), and m5 (spatial thinking index) in comparison with the initial data.

This is a sign of an improvement in the attention, recent memory, and associate-spatial thinking functions. At the same time, the increase in TPE is a sign of impaired precision of time perception (Tab. 5). Thus, by the middle of the school year, the girls demonstrated both an improvement in psychical functions and a deterioration of time perception.

The final examination of the girls found a significant increase in the indices of abstract (m1), logic (m3), operational (m4), and spatial (m5) thinking, as well as a decrease in TPE and associative thinking (m2) indices in comparison with the beginning and middle of the school year (Tab. 5). These results reflect an improvement in the psychical functions of perception and thinking by the end of the school year in comparison with its middle.

According to Table 6, TPE significantly increases in the boys by the middle of the school year. This is a sign of impaired time perception. At the same time, RMV increases significantly. By the end of the school year, the boys show a significant decrease in TPE. LPVMR, LPAAMR, and m2, as well as a significant increase in RMV, STMV, m1, m3, m4, m5, FLNP, and BE (Tab. 6).

Our data reflect an improvement in the boys' psychical functions of perception, memory, and thinking, shortening of the latent periods of sensory-motor reactions, combined with reduced lability of the neurodynamic characteristics of the CNS by the end of the school year. These changes reflect a significant increase in brain efficiency.

By the end of the school year, some psychical and neurodynamic functions improve both in the girls (Tab. 5) and in the boys (Tab. 6). At the same time, together with an insignificant decrease in the voluntary attention volume, associative thinking deteriorates; additionally, the boys show a reduced functional lability of nervous processes (Tab. 6). This reflects, firstly, an improvement in psychophysiological functions due to learning and, secondly, fatigue, which manifests itself in the impairment of voluntary attention, associative thinking, and functional lability of nervous processes.

Discussion

Thus, the formation of psychical and neurodynamic functions in junior schoolchildren is characterized by a gradual involvement of new elements of the functional system in learning. The increase in the recent memory volume in the middle of the school year, combined with more frequent time perception errors, is the psychical mechanism that permits the formation of new systemic interrelations. This reflects weakening determinism and strengthening of the stochastic nature of the psychical organization functions during learning (Korobeynikov, 2001). This stochastic nature makes it posible to search for the optimal result of the functional system during the formation of psychical functions in junior schoolchildren. The result of this search is an improvement in associative-spatial thinking and an increased voluntary attention volume, which are significant in the girls.

The physical development is inseparable from the formation of the psychical and neurodynamic functions in junior schoolchildren. Learning inevitably leads to fatigue, which may affect the effectiveness of psychical functions and impair physical development. At the same time, the physical development level is an important factor of the formation of psychical functions during learning.

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