

PHYSIOLOGICAL ADAPTATION OF MODERN UKRAINIAN PRESCHOOLERS

Fizjologiczna adaptacja współczesnych ukraińskich przedszkolaków

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A- przygotowanie projektu badania (study design), **B-** zbieranie danych (data collection), **C-** analiza statystyczna (statistical analysis), **D-** interpretacja danych (data interpretation), **E-** przygotowanie maszynopisu (manuscript preparation), **F-** opracowanie piśmiennictwa (literature search), **G-** pozyskanie funduszy (funds collection)

Summary

Introduction: High demands of modern social environment to the child's individual development are connected with their health decline and wide variation of individual capabilities. Because of such inconsistency decreased functional abilities are being observed in preschoolers. It leads mainly to health problems and developmental disorders. Body adaptive properties are considered to be the integral indicator of health. Researches find high prevalence of the lack of adaptation among children of different age groups which might lead to low quality of life.

Aim of the study: The aim of the research was to estimate preschooler's cardiovascular system functioning and the adaptation abilities based on the examples of children from Ternopil, Ukraine.

Material and methods: 170 healthy preschoolers were among the participants of the research. Anthropometry and the assessment of some hemodynamic parameters were performed to draw conclusions about the level of their cardiovascular capacity.

Results: Only 54.7% of the examined children reflect the satisfactory level of cardiovascular system adaptation. The deviations mainly result from high BMI, Rate Pressure Product and abnormal reaction of the autonomic nervous system after a squatting test.

Conclusions: Simple noninvasive methods (functional changes index, pulse rate and blood pressure and the indicator of arteries' pressure) help to identify children with reduced circulatory response to stress and physical burden.

Keywords: preschoolers, cardiovascular adaptation

Streszczenie

Wstęp: Wysokie wymagania współczesnego środowiska społecznego wobec indywidualnego rozwoju dziecka są związane z ich niskim poziomem zdrowia i dużym zróżnicowaniem adaptacji poszczególnych funkcji organizmu. Z powodu takiej niezgodności u dzieci w wieku przedszkolnym obserwuje się zmniejszenie zdolności funkcjonalnych. Prowadzi to do problemów zdrowotnych i zaburzeń rozwojowych. Właściwości adaptacyjne organizmu są uważane za integralny wskaźnik zdrowia. Wczesne badania pozwoliły znaleźć wysoką częstość dysadaptacji dzieci z różnych grup wiekowych, co może prowadzić do zmniejszonej jakości życia.

Cel badania: Celem przeprowadzonych badań była ocena funkcjonowania układu sercowo-naczyniowego i określenie zdolności adaptacyjnych na przykładzie dzieci z Ternopola na Ukrainie.

Materiał i metody: W badaniach uczestniczyło 170 zdrowych przedszkolaków (w wieku 3-5 lat). Badanie pomiarów antropometrycznych i niektórych parametrów hemodynamicznych przeprowadzono w celu określenia poziomu adaptacji i dyzadaptacji układu sercowo-naczyniowego dzieci.

Wyniki: Jedynie 54,7% badanych dzieci posiada zadowalający poziom ogólnego dostosowania się układu krążenia. 45,3% przedszkolaków wykazuje ogólne odchylenia adaptacji (wysoki BMI, wysokie ciśnienie krwi, nieprawidłowe reakcje układu sercowo-naczyniowego i nerwowego w próbie wysiłkowej).

Wnioski: Proste nieinwazyjne metody (definiowanie wskaźników antropometrycznych, pulsu i ciśnienia krwi oraz obliczenia indeksu zmian funkcjonalnych, wskaźnik ciśnienia tętniczego) mogą pomóc w identyfikacji dzieci z obniżonym poziomem odporności układu krążenia na stres i obciążenie fizyczne.

Słowa kluczowe: przedszkolaki, układ krążenia, adaptacja

Background

Children represent the future, and ensuring their healthy growth and the development ought to be of a prime concern of all societies. As for preschoolers, ensuring their health care is performed by parents and preschool education institutions at preschool age. According to direction [1], the main goals of preschool education are preservation and strengthening of the physical, mental and spiritual health of the children, the development of their creativity and social skills. Systemic purposeful work with 4-5 year old kids is necessary to dissolve important educational, psychological and social problems of providing equal starting opportunities of the children. The experience of many countries indicates the need and importance of such work with children during this age period when the intensive brain development and the formation of cognitive activity are present [2, 3].

According to the statistics and researches, the proportion of healthy children has decreased in recent years. And such complexity of educational programs of preschool education establishment require a high level of mental development in preschoolers, verbal capabilities and functional systems which determine the quality of adaptation [4]. However, the determination of functional maturity of the preschooler's body and their school readiness is important for doctors and teachers.

It is known that stress does not affect everyone in the same way. Stress may be caused by disadaptation and neurotic disorders in some persons. Researchers found that physiological adaptation of children depends on the physical and mental development, illness, education environment, social status of a child's family and sex [5, 6].

Adaptation is considered as an integral indicator of human health. It reflects the degree of dynamic equilibrium between an organism and microenvironment. Adaptation is determined by the level of the reserve capacity of major functional systems. It can expand or limit the intensity and duration of adaptive capacities and show the balance between the organism and the environment [5, 7].

Researchers found that the success of adaptation responses depends on the function of the cardiovascular system, too [7]. The evaluation of cardiovascular function involves the study of stress regulatory mechanisms and functional reserve mobilizing systems [8, 9]. It takes into account a wide range of hemodynamic parameters and its changes under different loads [10, 11].

We have decided to estimate preschooler's cardiovascular adaptation and some features of its background.

Material and methods

4-5.5 year old children attending preschools (n=170), citizens of Ternopil region: 83 (48.8%) boys

and 87 (51.2 %) girls were examined in the study. They had not had any cardiovascular pathology in the past. Before testing, the informed consent was obtained from the children's parents or guardians. The study was approved by the local Ethical Committee of University. The management of examination included anthropometry (weight (W), height (H), calculation of body mass index (BMI) as weight in kilograms divided by the square of height in metres (kg/m²)). Anthropometry results were standardized according WHO Child Growth Standards. We assessed some hemodynamic parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) using semi-automatic blood pressure monitor OMRON Compact (Japan). We used this data to determine the functional ability of child's cardiovascular system and its adaptation capacity such as:

- Pulse pressure (PP) was calculated by subtracting the diastolic pressure from the systolic pressure (mm Hg);
- Stroke volume (SV) was calculated using the following formula [12]
- $SV = 0.53 \times SBP + 0.617 \times H + 0.231 \times W - 1.07 \times DBP - 0.698 \times A - 22.64$ (where A-age; 22.64; 1.07; 0.698; 0.617; 0.53 i 0.231 – multiple regression equation coefficients) (ml);
- Cardiac output (Q) was calculated by multiplying stroke volume by heart rate (ml/min);
- Endurance factor (EF) was calculated using the following formula [13]
- $EF = HR \times 10 / PP$
- The level of adaptive capacity of cardiovascular system was determined by of functional changes index as (FCI) [14].

$FCI = 0.011 \times HR + 0.014 \times SBP + 0.008 \times DBP + 0.014 \times A + 0.009 \times W - 0.009 \times H - 0.27$ (where A-age; 0.27 - standard deviation).

According to the value of FCI, we determined the level of "adaptive capacity" (AC): less than 1.89 as satisfactory, from 1.90 to 2.14 – as tense of adaptation, from 2.15 to 2.41 as poor adaptation and more than 2.42 – as the adaptation failure. Such figures have been found after statistical analysis of functional changes index of Ukrainian children [6].

- Double product (DP) was calculated as the product of heart rate and systolic blood pressure.

The data obtained were analyzed statistically with the use of StatSoft Statistica 6.0. The results were presented as arithmetic means and standard deviations (SD). Calculation of relative values and determination of their validity were carried out under statistical processing in most cases. The t-test for paired samples was applied. The differences between the relative values of the compared groups were evaluated using the test ϕ (Fisher's exact test). The level of statistical significance was set at $p < 0.05$.

Results

Reserve capacity of the organism depends on the adequacy and the level of its growth and development, which are determined by a set of morphological and functional properties of an organism. The results of anthropometric examinations of children are presented in table 1.

Table 1. Sex difference in anthropometric measurements

Variable	Male (N =83) mean±SD	Female (N =87) mean±SD
Weight (kg)	21.1±3.9	20.3±3.4
Height (cm)	115.4±5.5	113.6±5.4
BMI (kg /m ²)	15.8±1.9	15.6±1.8

Figures 1 and 2 show the children's weight and height difference.

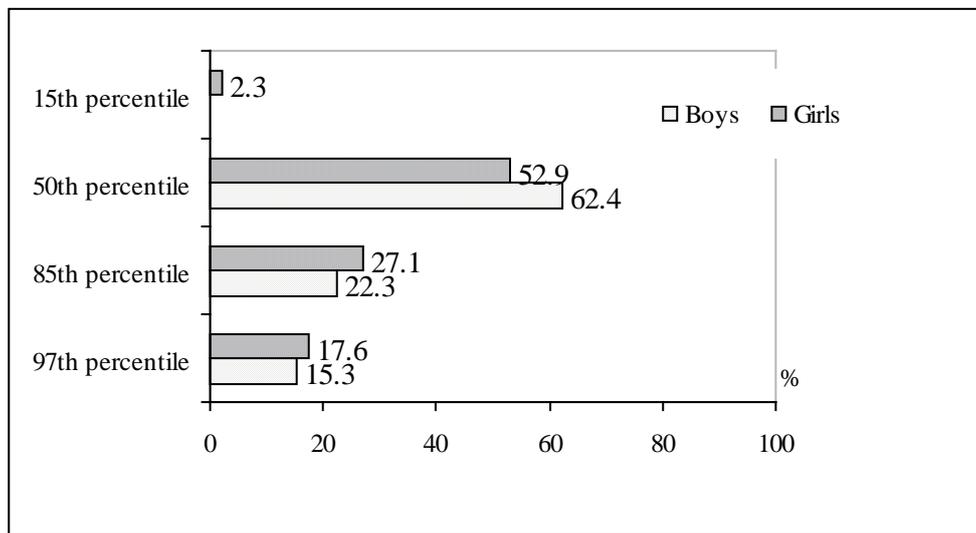


Figure 1. Distribution of percentile for weight

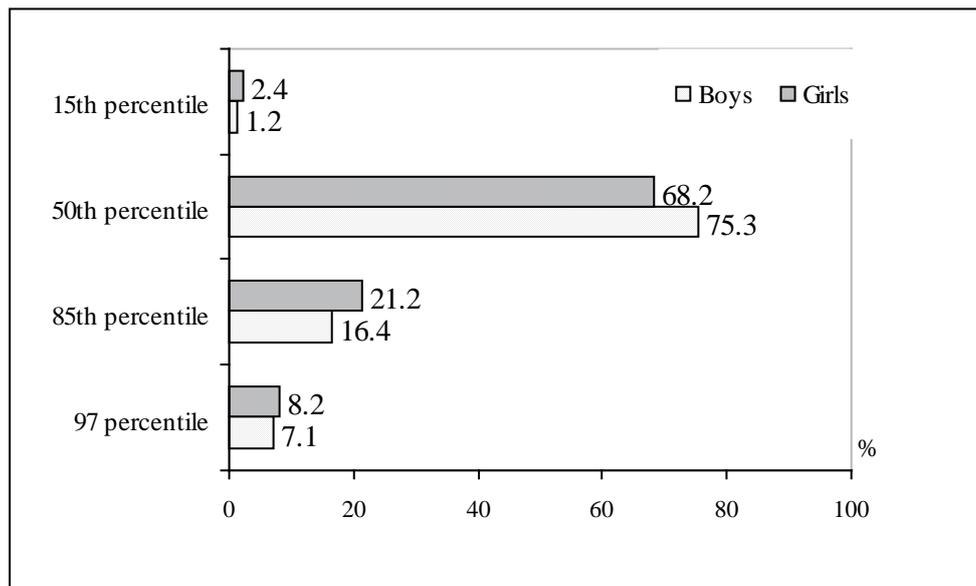


Figure 2. Distribution of percentile for height

We found about $72.4 \pm 3.4\%$ of examined children were in the 15-85th percentile for BMI, $11.2 \pm 2.4\%$ - less than 15th percentile, $16.5 \pm 2.9\%$ - greater than 85th percentile.

According to the functional testing of the cardiovascular system in children (table 2) it was found as age norm.

Table 2. Descriptive statistics of the cardiovascular parameters

Variable	Value							
	Boys (N=84)				Girls (N=86)			
	Min.	Max.	Me	σ	Min.	Max.	Me	σ
HR (bpm)	65	115	87.0	10.2	78	157	91.5	13.4
SBP (mmHg)	88	131	104.5	7.6	87	131	103.5	8.1
DBP (mmHg)	45	85	59.5	7.3	43	85	60.0	7.7
PP (mmHg)	20	64	44.0	7.5	22	64	42.0	7.7

Normal range of heart rate was identified in 66.4% of children, tachycardia (more than 126 bpm) - 1.5%, bradycardia (less than 86 bpm) - in 32.1% of children.

Analysis of the SBP level showed the normal range in 90.1% of children, increased (above 116 mmHg) - in 4.1%, lower (below 86 mmHg) - 5.3% of children. Normal

range of DBP level (48-66 mmHg) was determined in 86.3% of children. In 6.1% of the examined it was lower, in 7.6% of cases – higher than relative upper limit of normal range. Difference of SBP and DBP is not found to be statistically in children of both sexes ($p > 0.05$).

Table 3. Cardiovascular calculated indexes in children

Variable	Value							
	Boys (n=83)				Girls (n=87)			
	Min.	Max.	Me	σ	Min.	Max.	Me	σ
SV (ml)	20.7	59.2	40.6	7.6	12.9	57.4	39.0	7.6
Q (ml/min)	2168.4	5380.1	3472.7	717.4	1379.4	5588.5	3475.6	773.2
FCI (Un)	1.31	2.40	1.85	0.20	1.48	2.81	1.85	0.24
EF (Un)	13.4	53.5	20.1	5.4	13.4	48.6	22.5	6.1
DP (Un)	58.5	138.0	92.1	13.9	68.7	172.7	94.8	18.0

$30.1 \pm 3.5\%$ of the children had satisfactory (high, high intermediate, intermediate) hemodynamic response, $69.9 \pm 3.5\%$ - unsatisfactory (low and low interme-

diate) (figure 3). Boys make up about $28.2 \pm 4.9\%$ of children with unsatisfactory poor quality regulation, girls – $31.8 \pm 5.1\%$ of them.

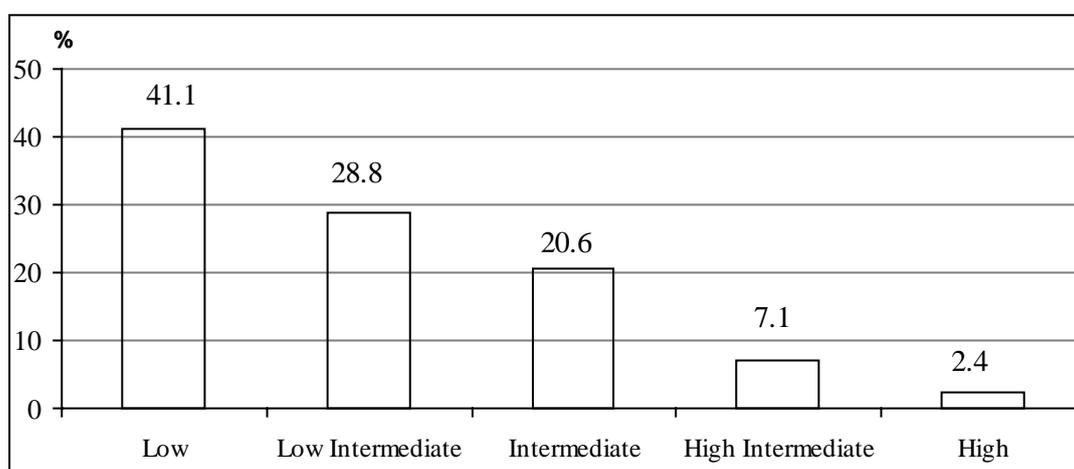


Figure 3. Distribution of children in terms of quality regulation of the cardiovascular system

Boys make up about $28.2 \pm 4.9\%$ of children with unsatisfactory poor quality regulation while girls – $31.8 \pm 5.1\%$ of them.

Figure 4 illustrates the levels of adaptation based on FCI values.

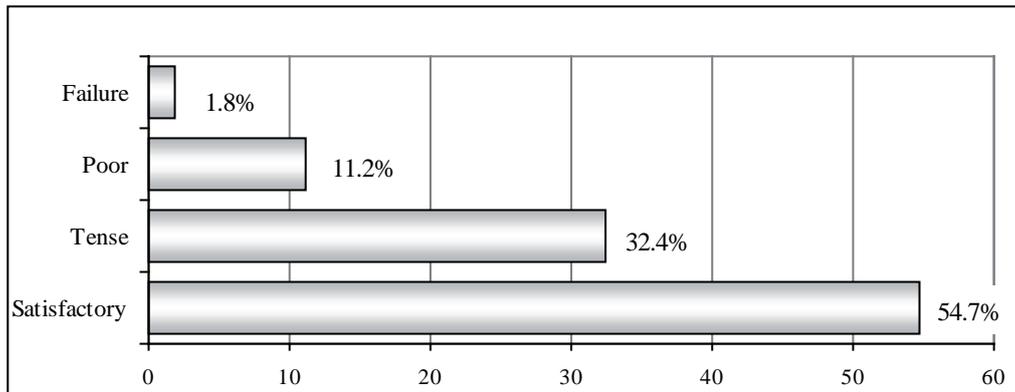


Figure 4. The levels of adaptive capacity of children

The mean value of boys' FCI was 1.87 ± 0.20 units while girls' – 1.92 ± 0.20 units, indicating relatively higher ($p > 0.05$) boys' adaptive cardiac response.

Next part of our investigation was to determine disadaptation trigger factors. The relationship and interference between the adaptive capacities level and child's physical development were confirmed by some researches. Our results showed BMI of children with decreased adaptation capacity level was significantly

higher (19.5% vs. 9.7%; $\varphi = 1.83$, $p < 0.05$). Double product also was recognized as significantly higher (80.5% vs. 8.6%; $\varphi = 10.59$, $p < 0.01$) in these children's group and mean low myocardial energy metabolism.

Squatting test was performed for determination of features of systems tension in children with a different adaptation level. Results are presented in figure 5.

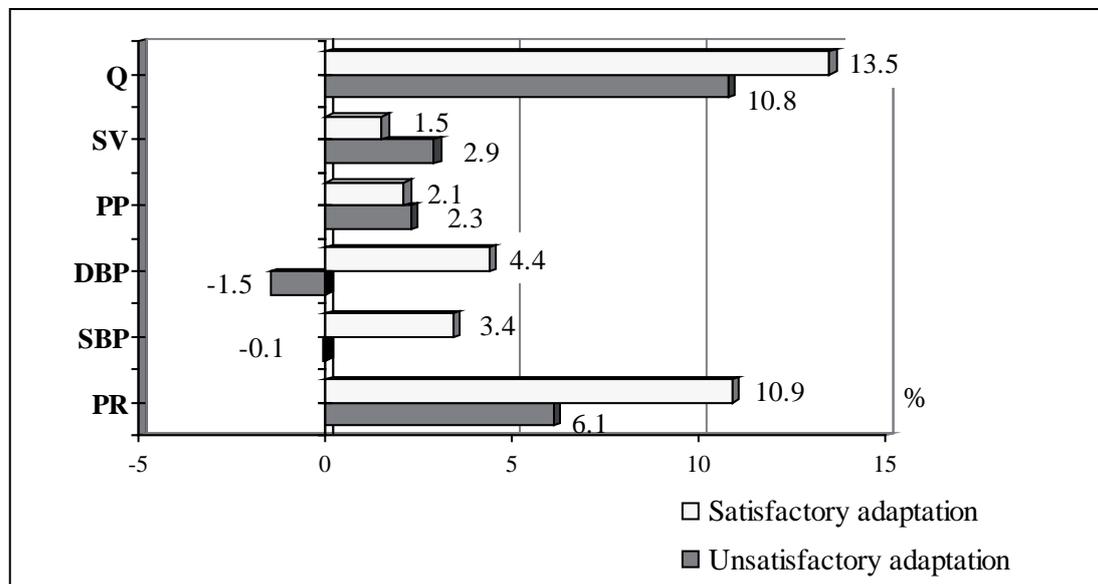


Figure 5. Gain of cardiovascular parameters in children with different adaptation level after physical load.

Discussion

Considering the features of preschool children social adaptation, it is important to take into account incomplete development of functional systems and consider together all the manifestations of adaptation such as behavior, autonomic changes, the changes in reactivity and increased morbidity and the changes in mental and physical status.

It is considered the presence of external and internal adaptability criteria. The result of external criterion is to achieve socially desirable behavior which is the environmental compliance. The internal criterion is general psychophysiological well-being which is a subjective feeling of comfort associated with the ability of need satisfaction and self-expression. Adequate adaptability requires consistency among these two criteria. Disadaptation caused by external criterion

is manifested in abnormal behavior, and caused by internal - emotional stress, neurotic conditions that lead to poor health and reduced performance.

"Adaptive capacity" (AC) is considered as the most accurate measure of adaptation and is frequently used as the criterion of adaptive cardiac response to stress also in children. It defines the possibility to maintain a balance between the child and the environment through the mobilization of cardiovascular functional reserves. Our study has found only approximately 54.7% of children with adequate adaptation, another 45.3% reflect different levels of disadaptation. It does not depend on the children's sex. This data was followed by pathologic deviations of some functional circulatory parameters (stroke volume, cardiac output and endurance factor). As the results of other investigations of schoolchildren adaptation [6, 15], our study has confirmed some negative trends such as increased frequency of unsatisfactory adaptation levels of children.

Among other indicators, double product is a surrogate measure of myocardial oxygen demand and cardiac workload used increasingly today in medicine [11]. Our studies have shown that $41.2 \pm 3.8\%$ of the total number of children have poor quality of regulation at rest. It was not correlated with gender differences. Significantly more often poor quality of regulation at rest was present in children with symptoms of disadaptation: 100.0% vs. $45.2 \pm 5.2\%$ of children with satisfactory level of adaptation ($p < 0.05$).

The squatting test is an active posture maneuver that imposes one of the most potent orthostatic stresses. In normal subjects, the changes in blood pressure and heart rate are transient because of appropriate baroreflex homeostasis and do not provoke symptoms. Squatting has been used to early detection of altered vagal and/or sympathetic function [8]. We have analyzed the hemodynamic pattern during a squatting test in children. Both systolic blood pressure and diastolic blood pressure at rest and after squatting test were significantly reduced in children with decreased adaptation capacity level. This data confirms abnormal (reduced) circulatory response to exercise.

Conclusions

The normal range of main parameters of the cardiovascular system of preschoolers does not mean a good condition of their cardiovascular capacity. Simple noninvasive calculated data (functional changes index, rate pressure product) help identify children with reduced circulatory response to stress and exercise. It is important to perform a squatting test for the investigation of children's spare capacity for prevention of unexpected reaction to an impact.

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